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EDITORIAL

THE COCONUT RESEARCH SCHEME

SINCE the compilation of our last number the Coconut Research Scheme of Ceylon has made history by opening its laboratories. This is the last of the three schemes established in the Island to start scientific investigation with the idea of effecting a betterment in the production of its major products. The Coconut Research Scheme, and the others likewise, have one great object—to investigate—and then to recommend the possibilities of the results of such investigation as will "deliver the goods" in greater quantity or better quality. Industrial research implies that difference from fundamental, or what is sometimes styled, pure research, in that it requires delivery of the goods. All enquiry into the cause of things as to lead to the expansion of knowledge may eventually have an influence on human progress but industrial research differs somewhat from much of such enquiry in that it is investigation to order, not to bring about so much an enlargement of knowledge but a direct application of knowledge to the advancement of industry. The fundamental work, the patient probing of his theories and their application by the scientist may be lost to the industrialist, with him the result is the thing.

There is a large amount of capital sunk in Ceylon in her coconut plantations and this capital is in the main that of Ceylonese whose forebears have by the industry and care acquired coconut property. Any real benefit that can be bestowed upon this industry at the present or future time will be singularly appreciated. The Scheme starts its work in the

first instance with moderate pretensions. Attempts to improve the race of coconut palms so as to secure an increased yield will be the work of the geneticist, investigations to effect improvement in the yield of individual trees through a study and amelioration of the soil around them will engage the attention of a Soil Chemist, whilst a second chemist will devote his attention to the manufacture of the products of the palm so as to deliver them to the market or consumer in the most acceptable form.

There are great industrial possibilities for Ceylon in the coconut palm. An increase in the yield of nuts could be accompanied by large extraction of their oil in the country itself instead of shipping the raw product to have the oil taken out elsewhere. The past year has seen the inception of such a move, research can do much toward its continuance. The oil itself offers opportunities as yet untouched in the Island for the manufacture of the many products for which it is suitable. The encouragement of an industrial sense among the people of Ceylon so as to manufacture some of their agricultural raw produce into consumable form cannot be other than beneficial to the Island. For such, the coconut offers opportunity. A very valuable "Survey of Coconut Palm Products" has recently been published by the Empire Marketing Board and it is encouraging to read of the possibilities of development of the oil pressing industry in the country of production. "This development indicates that the crushing industries in the copra-producing countries are successfully competing with the industries in the centres of consumption and this tendency may be expected to continue."

The Philippine Islands and the Dutch East Indies are the greatest coconut producing areas. Ceylon shares third place with the British South Sea Islands whose coconut products are about one-third those of the two premier producers.

The United States takes very largely of the Philippine exports which enjoy a tariff exemption imposed on coconut oil from all other sources.

It is possible that the future may see a great advance in the use of coir.

To the coconut industry of Ceylon the Research Scheme is capable of rendering great services and it is to be hoped that progress in the industry will be the visible signs of its existence.

A SOIL EROSION EXPERIMENT

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INTRODUCTORY

IN the year 1923 a Sub-Committee of the Estate Products Committee of the Board of Agriculture was appointed under the Chairmanship of Mr. F. A. Stockdale, Director of Agriculture, to consider the question of soil erosion.

The last of the recommendations of that Committee was "That further experiments should be carried out by the Agricultural Department to determine in Ceylon the amount of soil erosion which is annually taking place in the planting districts." Anyone who has had to do with an experiment designed to measure soil erosion with any degree of accuracy will have learnt that each such experiment is an operation of considerable magnitude, involving expensive structural work, frequent measurements, the determination of moisture or dry matter in samples, and a great deal of careful supervision.

Actually the only outcome of the recommendation quoted above was the inauguration, on the Experiment Station, Peradeniya, of the experiment which is described in this paper.

Work was started in July 1925 and the actual recording of erosion began from June 1st, 1926.

DESCRIPTION OF THE EXPERIMENT

An area of steep tea land of a uniform slope was chosen and was marked out into six long plots running down the slope. Each plot was 96 feet long and 15 feet across. A brick drain, however, occupied two feet at the side of each plot leaving an area of 13 feet by 96 feet, or approximately one thirty-fifth of an acre over which erosion would actually take place. In each plot there were five contour drains each running into the brick down-drain at the side of the plot, the outer wall of this down-drain being of sufficient height to prevent any soil from the neighbouring plot finding its way into the drain. A brick

wall at the top of each plot prevented the entrance of soil from above. The brick down-drains led into brick pits faced with cement and these pits occupied the entire width of the plots. Thus, all the soil which was washed off each plot, either by way of the drains or directly down the slope, eventually found its way into the pit at the bottom. The pits were 15 feet long, by 2 feet 3 inches wide. The depth at the lower side was 3 feet 6 inches, the height of the wall at the top side being regulated according to the level of the soil at that point.

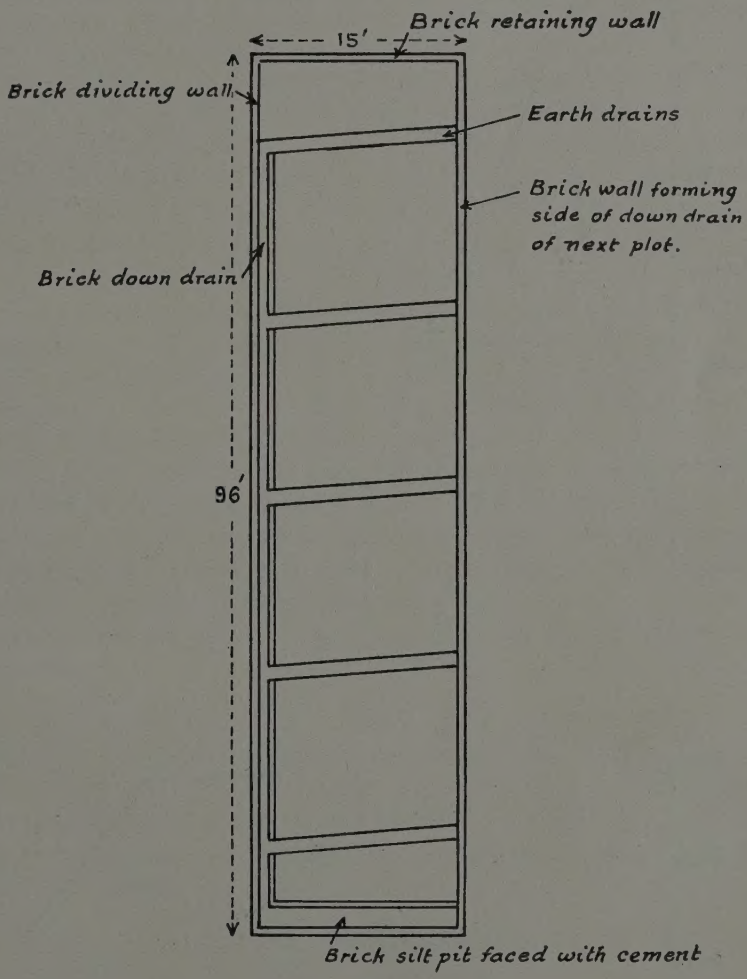
A plan of a single pit is shown in the diagram. The slope would be classed by the casual observer as very steep; actual measurement showed the gradient to be between 29° and 31°. Each plot contained between fifty-five and sixty-three tea bushes, including young supplies, at the beginning of the experiment. Gliricidia was interplanted in the tea approximately 16 feet by 16 feet, the number of trees in each plot varying between four and six.

The method of recording results was as follows: below the silt pits two cement tanks were built—one to serve three silt pits. These tanks were graduated in litres and were fitted with drain plugs. After a heavy fall of rain the silt pits held a considerable quantity of water which contained a good deal of fine soil in suspension, and at the bottom a deposit of sand and other heavy material. When there was sufficient water in the silt pits to warrant the operation the liquid in the tanks was syphoned off by means of a hose-pipe into the measuring tank below. The quantity of water drawn off from each pit was recorded, the liquid well stirred, and a sample taken for the determination of dry matter in suspension. From this the total amount of dry soil removed in suspension from each plot was calculated.

The solid matter remaining in the pits was only dealt with once or twice in a year. The soil was well mixed, and after weighing a sample was taken for determination of dry matter content. A complete record of the weight of dry soil removed from each plot was thus obtained.

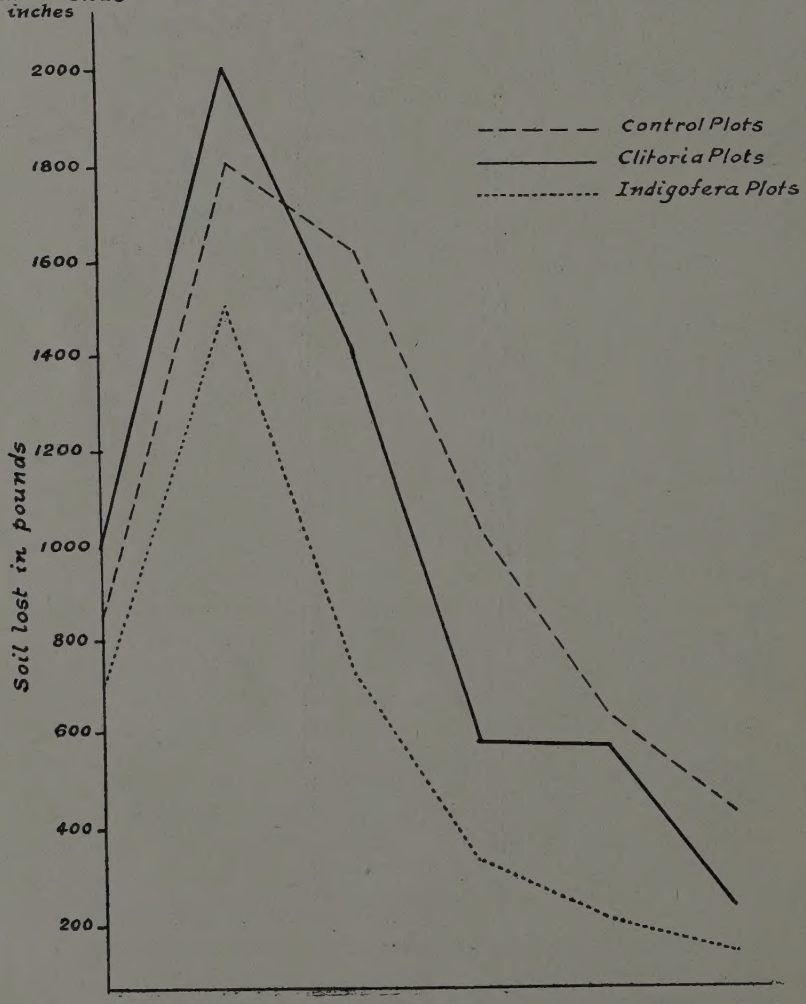
Although the recommendation of the Committee alluded to above only covered the question of measurement of actual erosion it was felt that this might well be combined with a test

PLAN OF A SINGLE PLOT



Actual Loss of Soil in pounds per two plots under each treatment.

	1926-27	1927-28	1928-29	1929-30	1930-31	1931-32
	No treatment	Indigofera and Clitoria planted				
Rainfall in inches	87.29	80.90	89.03	99.70	81.25	104.66



of the efficiency of one or two methods of checking erosion. It was therefore decided that two out of the six plots should be planted all over with *Indigofera endecaphylla*, two with hedges of *Clitoria cajanifolia*, while the remaining two plots were to serve as controls.

During the first year of the experiment, 1926-27, no treatments were applied, in order that an idea of the differences in erosion between the different plots might be obtained. In June 1927, *Indigofera endecaphylla* cuttings were planted all over plots 1 and 4 while in plots 2 and 5 a thick hedge of *Clitoria cajanifolia* was sown above each drain. The *Indigofera* in plot 1 grew well over most of the plot but in one portion at the bottom of the plot it never became properly established. A satisfactory uniform cover was obtained in plot 4. The *Clitoria* hedges in every case grew well from the start and the plant has proved most satisfactory as a contour hedge plant. The planting of the *Indigofera* and *Clitoria* naturally caused considerable disturbance of the soil and probably resulted in additional erosion for a time. Records of erosion were continuously maintained from June 1st, 1926 to May 31st, 1932. During that period no operation was undertaken which might effect the question of erosion which was not equally applied to all plots. Nothing was done to the *Indigofera* beyond cutting it back at the edges of the plot when it started to creep into the next plot or into the brick down-drain. The *Clitoria* hedges were regularly cut down to a few inches in height and the loppings laid along the ground above the hedges.

In the last two or three years of the experiment a certain amount of trouble was experienced from slow leakage of water from the pits. It was thought, however, that no appreciable amount of soil was lost—in any case the amount of soil removed in suspension in the liquid formed a very small fraction of the total eroded soil.

RESULTS AND DISCUSSION

The losses of soil from the two plots under each treatment are shown with other figures of interest in table I while the graph shows the actual soil loses over the whole period. Rainfall figures are also included.

Table I

Losses of Soil during the Experiment.
The figures in brackets represent the percentage of the Controls.
Two plots of 1/35 acre for each treatment.

Year	Control plots lb.	*Indigofera* plots lb.	*Clitoria* plots lb.
1926-27 (No treatments)	863·8 (100)	738·1 (85·4)	1055·7 (122·0)
1927-28 (*Indigofera* and *Clitoria* planted)	1810·9 (100)	1538·4 (84·9)	2069·6 (114·3)
1928-29	1733·1 (100)	723·3 (41·7)	1416·6 (81·7)
1929-30	1039·7 (100)	321·8 (30·9)	577·9 (55·6)
1930-31	651·4 (100)	201·5 (30·7)	562·9 (86·4)
1931-32	432·4 (100)	127·5 (29·4)	236·6 (54·7)
Total	6531·3 (100)	3650·6 (55·8)	5919·3 (90·6)
Losses for 5 years after planting *Indigofera* and *Clitoria*	5667·5 (100)	2912·5 (51·3)	4863·6 (81·8)
Average annual erosion 1927-28 to 1931-32 expresses as percentage of 1926-27 erosion (before application of treatments).	131	79	92
Total loss in tons per acre in 6 years	101·8	56·7	92·4
Loss in inches of top soil in 6 years	·81	·45	·74
Average loss of soil in inches per annum	·135	·075	·123

Several points call for comment. First there is the remarkable increase in erosion in all plots in 1927-28, the year at the beginning of which the *Indigofera* and *Clitoria* were planted. All who are familiar with agriculture on steep slopes in the tropics will realise that it is not the total rainfall in a month or a year which affects the amount of erosion but the *intensity* of that rainfall. This is well exemplified in the graph where it will be noted that the largest amount of erosion actually occurred in the year of the smallest rainfall and *vice versa*. Even an examination of the daily rainfall records sheds very little more light on the question. As an example of this it may be mentioned that there were seven days in 1926-27 in which more than two inches of rain fell in one day and an exactly similar number of such days in 1927-28; yet the amount of erosion in the second period was approximately double that of the first. To correlate rainfall with erosion it would be necessary to record the hourly

precipitation during the whole period of the experiment. With the idea of obtaining such information a clock-work recording rain gauge was obtained on loan from the Government Observatory but the instrument gave trouble from the start and was not found a success.

The increase in erosion in 1927-28 might be attributed to the disturbance of the soil occasioned by the planting of the *Indigofera* and *Clitoria* if it were not for the fact that a similar rise occurred in the control plots. It is perhaps significant that in April 1928, 9·23 inches of rain fell in six days and that on only one of those six days was the fall less than one inch. At any rate, in the absence of any other explanation, it must be concluded that the general increase in erosion in 1927-28 was due to precipitations of great intensity, though no adequate record of such precipitations exists.

A second noteworthy point is that while the *Indigofera* plots, and to a less extent the *Clitoria* plots, have shown a satisfactory diminution in erosion compared with the controls, the erosion in the latter plots has also declined steadily. This steady improvement in the control plots is somewhat hard to explain satisfactorily. It is possible that the number of really severe precipitations may have fortuitously decreased since 1927-28, but there are other tentative explanations that may be put forward. Before the start of the experiment the plots were forked at least once a year. The last such forking took place in November 1924, since when manure has only been applied just above the bushes and no general forking of the plots has been done. A minimum of soil disturbance from cultivation has therefore occurred. Further a considerable disturbance of the soil took place in 1925 owing to the filling up of the old drains and digging of new drains as shown in the plan. It is possible that the effect of this disturbance was still being felt in 1926-27, and that the erosion for that year was above normal. Assuming then that the abnormal erosion in 1927-28 was caused by precipitations of particular severity it is probable that the soil disturbed by the digging of drains in 1925 gradually became consolidated and erosion consequently progressively diminished.

Another point worthy of notice is that all tea vacancies were supplied in May 1926. This operation probably resulted in temporary additional erosion which subsequently gradually diminished. Moreover the tea plants then planted probably formed an increasingly efficient barrier to erosion as they grew older. Lastly, except on long bare slopes where gullying continues progressively, the removal of the looser surface soil by

erosion will automatically bring about a slowing down of soil movement until at last a state of stability is reached because, in the absence of abnormal circumstances, there is little soil left that can easily be dislodged.

Another point that appears in the graph is the rather remarkable check in fall of erosion in the *Clitoria* plots in 1930-31. No very satisfactory explanation of this is forthcoming but it must be borne in mind that small irregularities in the form of the land may have a powerful though possibly temporary effect on the amount of soil eroded.

The figures obtained from the experiment show that both the planting of a cover of *Indigofera endecaphylla* and the planting of thick contour hedges of *Clitoria cajanifolia* very appreciably retarded erosion though neither treatment reached within measurable distance of completely stopping soil loss. As was to be expected the creeping cover crop was most effective—in the last year of the experiment the soil lost from the two *Indigofera* plots was only 29·4% by weight of that weight lost from the control plots.

As regards the primary object of the experiment, the determination of the actual amount of erosion taking place, the figures of total loss of soil in tons per acre over six years furnish sufficient evidence of the menace to agriculture from unchecked erosion.

This loss is also shown in the form of loss of inches of surface soil and from this we can deduct that an inch of soil would be lost in 7½ years in the control plots, in 20 years in the *Indigofera* plots, and in 8¼ years in the *Clitoria* plots.

ANALYTICAL DATA

With a view to determining the changes, if any, produced in the constitution of the soils of the plots as a result of erosion, mechanical and chemical analyses of representative soil samples from the plots were made in 1928 and again in 1932. Table II below summarises the mean results obtained for organic matter, nitrogen, clay, and sand + gravel contents for the three pairs of plots.

Table II

	1928				1932			
	Nitrogen	Organic matter	Clay	Sand + gravel	Nitrogen	Organic matter	Clay	Sand + gravel
	%	%	%	%	%	%	%	%
Indigofera plots	·108	8·2	34·3	48·9	·136	9·0	22·9	49·3
Clitoria plots	·113	9·2	24·6	48·4	·121	8·3	22·4	50·7
Control plots	·099	9·1	25·5	47·9	094	8·1	22·7	51·4

It will be noted that while the *Indigofera* plots show appreciable increases in nitrogen and organic matter (loss on ignition) the controls show a small decrease in nitrogen and a fairly large decrease in organic matter. The *Clitoria* plots register a slight increase in nitrogen but a fall in organic matter. All the samples have shown losses in clay and gains in sand + gravel during the period. The largest average losses of clay and gain in sand + gravel occur in soils from the control plots, while the smallest average falls in clay and increases in sand + gravel content occur in those from the *Indigofera* plots. The analytical data therefore supply further evidence of the value and relative efficiency of a cover of *Indigofera* and contour hedges of *Clitoria* in preventing soil erosion.

Table III

	Organic matter	Nitrogen	Potash	Phosphoric acid	Clay
	%	%	%	%	%
Indigofera plots	12·0	·345	·232	·095	11·2
Clitoria plots	10·9	·195	·228	·087	17·5
Control plots	10·0	·189	·196	·085	15·4

In table III above are shown the percentages of organic matter, nitrogen, potash, phosphoric acid, and clay in samples of the eroded soil material. It is regretted that several such samples were not taken for analysis, but the data obtained furnish sufficient evidence of the very appreciable losses of soil fertilising constituents that occur through erosion. The percentages of organic matter, nitrogen, potash and phosphoric acid in the eroded material are all high and, especially in the case of nitrogen, much higher than those of the soils from which they have been derived. The largest percentages of fertilising constituents, especially of nitrogen, are found in the eroded material from the *Indigofera* plots and the smallest from the controls. The high nitrogen content of the eroded material from the *Indigofera* plots is doubtless due to the fairly large amounts of decomposed *Indigofera* leaf material found in these samples. As to be expected, the clay content of the eroded soil is lowest in the case of that from the *Indigofera* plots.

Whilst it would not be correct to assume that the composition of the eroded materials remains constant during the whole period of the experiment, it is considered that the figures of total fertilising constituents lost through erosion, obtained on the basis of a single set of analytical determinations, would give a rough idea of the actual amounts of the former so lost.

Table IV gives the amounts in lb. per acre of the three fertilising constituents lost annually during the period 1925 to 1932 from the respective plots.

Table IV

	lb. per acre		
	Nitrogen	Potash	Phosphoric acid
Indigofera plots	73·0	49·1	20·1
Clitoria plots	67·2	78·6	30·1
Control plots	71·8	74·5	32·3
Average	70·7	67·4	27·5

It will be observed from the table that the *Indigofera* and control plots have lost almost the same amounts of nitrogen, and the *Clitoria* and control plots about the same amounts of potash and phosphoric acid. The least losses of the two latter constituents occur from the *Indigofera* plots. The high soil nitrogen loss from these plots is obviously due to the decomposed *Indigofera* leaf debris.

SUMMARY AND CONCLUSIONS

1. An experiment was carried out with the object of ascertaining (a) the amount of erosion actually taking place on steep tea land and (b) the extent to which a cover of *Indigofera endecaphylla* or contour hedges of *Clitoria cajanifolia* would check such erosion.
2. It was found that the weight of soil lost in six years from the control plots amounted to 101·8 tons per acre or nearly 17 tons per acre per annum, while in the same period 56·7 tons or nearly 9½ tons per acre per annum were lost from the *Indigofera* plots, and 92·4 tons or nearly 15½ tons per acre per annum from the *Clitoria* plots.
3. The amount of erosion showed a large increase in all plots in the second year of the experiment and thereafter rapidly diminished. Possible reasons for this are discussed.
4. Neither the cover of *Indigofera* nor the contour hedges of *Clitoria* came within measurable distance of completely stopping erosion, but the average annual erosion in the *Indigofera* plots over five years amounted to 79 per cent. of the erosion from the *same* plots in the first year, before the planting of the cover, while in the *Clitoria* plots the corresponding figure was 92 per cent.

5. The analytical data of representative soils from the plots taken in 1928 and again in 1932, indicate large increases in nitrogen and organic matter contents in the case of the *Indigofera* plots but decreases in the case of the controls. The *Clitoria* plots show a slight increase in nitrogen. All the plots register losses in clay and gains in sand + gravel, but the smallest losses of the former and gains of the latter occur from the *Indigofera* plots; the reverse is the case with the control plots.

6. Analyses of the eroded soil materials show the *Indigofera* plots to contain highest and the control plots lowest percentages of potash, phosphoric acid and nitrogen. The *Indigofera* eroded soils contain the lowest clay percentages. The eroded soil material is generally richer in fertilising constituents than the parent soil material from which it is derived.

7. On the basis of the analytical figures obtained, the total amounts of soil fertilising constituents lost through erosion are found to be very appreciable. On the average about 71 lb. of nitrogen, 67 lb. of potash and 27 lb. of phosphoric acid are lost from an acre of these soils annually. The lowest losses of potash and phosphoric acid occur from the *Indigofera* plots, but the nitrogen losses are highest from the control and the *Indigofera* plots. The observed high nitrogen losses from the latter plots are obviously due to the decomposed *Indigofera* leaf debris.

8. The analytical data furnish additional evidence of the value and relative efficiency of a cover of *Indigofera endecaphylla* and a contour hedge of *Clitoria cajanifolia* in checking soil erosion and the loss of soil fertility.

THE "BANANA" PASSION FRUIT

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THIS Passion fruit (*Tacsonia mixta* Juss.) is a perennial climber native of Peru and bears handsome pink, pendulous flowers and oblong fruits six to eight inches long. The fruits contain a pulp similar to that of the Passion fruit (*Passiflora edulis* Sims) which belongs to the same Natural Order, and are yellow when ripe and weigh, on an average, three ounces each.

It bears well at elevations from 5,000 feet upwards and is recommended not only for its fruit, but also as a handsome flowering climber which should be grown in every garden up-country where flowering climbers are so scarce.

It is propagated by seed and should be grown in well-drained soil enriched with cattle manure, and, preferably, on a fence or trellis-work where it can be kept under control and the fruits conveniently gathered. If allowed to ramble over trees it attains a height of thirty to forty feet.

The chief fruiting season is during September-November, although a few fruits are generally available throughout the year.

Interest is now being taken in the cultivation of this fruit and plants are being sent out from Hakgala for distribution among the villagers.

The photograph shows the fruits and flowers.

Photo *J. J. Nock*

The "Banana" Passion Fruit

CONTRIBUTIONS FROM THE RUBBER RESEARCH SCHEME (CEYLON)

FURTHER YIELD RECORDS IN CONNECTION WITH OIDIUM HEVEAE

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FOREWORD

IN Rubber Research Scheme *Quarterly Circular* Vol. 8, Part 4, a full account was given of experiments being conducted on Kandanuwara Estate, Matale, to investigate the effect of *Oidium* leaf disease, and of the sulphur dusting method of control, on the yield of severely affected rubber. Yield records kept during 1930 and 1931 showed that in the dusted field, where defoliation was almost entirely prevented in the latter year, the yield was maintained at a normal level, whereas the yield of the control field showed a considerable decline consequent upon the severe uncontrolled *Oidium* attack. The difference in yield of the two fields was most strikingly evident during the months immediately following the wintering period, when the one area possessed a good foliage of healthy young leaves while the other was suffering from severe abnormal defoliation. After comparison of the records with estate figures for yield per acre in previous years it was concluded that the sulphur dusting treatment had been responsible for a nett increase in yield of the order of 200 lb. per acre.

The following report summarises the yield records obtained during 1932.

DUSTING OPERATIONS

The sulphur dusting during 1932 was almost a complete failure owing to a mechanical breakdown of the machine. The rubber could not be satisfactorily dusted between the 20th January and the 2nd March, a most important period during which most of the trees developed their new foliage. Thus

despite applications of sulphur before and after this period the foliage of the dusted field was very little superior to that of the control. (Owing to the writer's absence on home leave actual figures indicating the comparative degree of defoliation in the two fields are not available). The effect on yield of the return of severe *Oidium* attack to the dusted field can be studied from the figures given below.

YIELDS

The method of recording yields in 1932 has been the same as that described for 1930 and 1931 in the publication mentioned above. In brief, yields are recorded every tapping from ten plots in each of the two fields, the number of trees in a plot being 16. The records are thus taken from the equivalent of one tapping task in each field, but this task is divided into ten plots scattered throughout the field. It is assumed that the summation of the yields from these ten plots is representative of the field as a whole.

The monthly yields of the two sets of plots for 1930, 1931 and 1932 are given in Table I, and represented graphically in Graph I. Owing to the monthly variation in the number of tapping days the actual yields from month to month would not be readily comparable. They have accordingly been reduced to a standard figure of 12 tappings per month, so that the figures represent the "yielding ability" during any month rather than the actual yield obtained. This figure for "yielding ability", which is a similar measure to the "yield per tapping" used in recording yields of mother trees and budgrafts, is essential for the study of the relationship between yield and foliage. No allowance has been made for trees out of tapping unless it has been clearly established that the reason for cessation of tapping is entirely extraneous.

GRAPH-I

MONTHLY YIELDS IN LBS RUBBER (160 TREES) PER 12 TAPPINGS

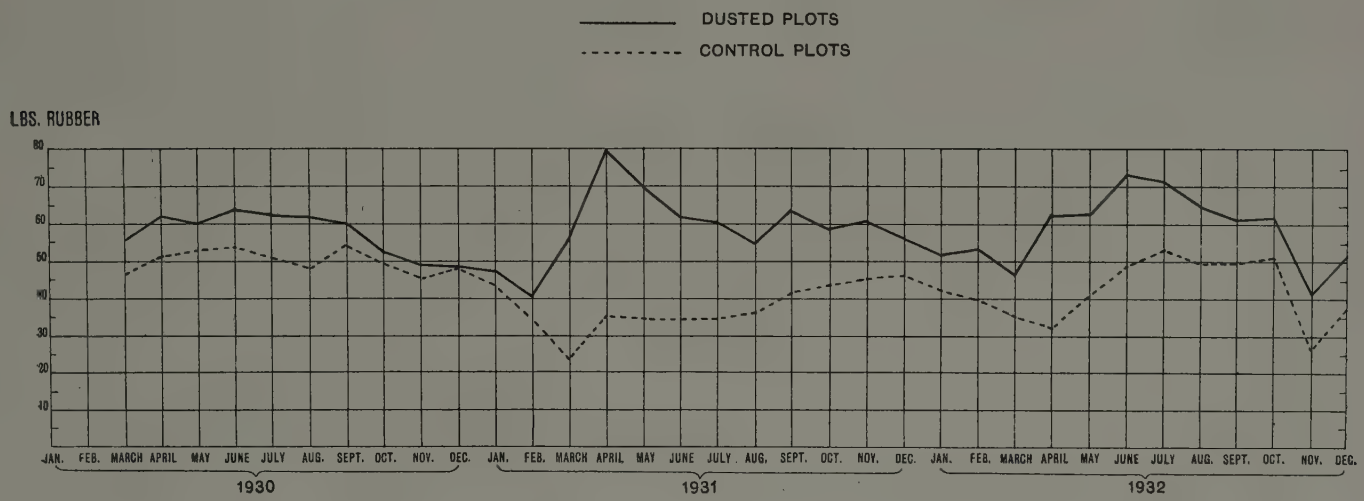


Table I

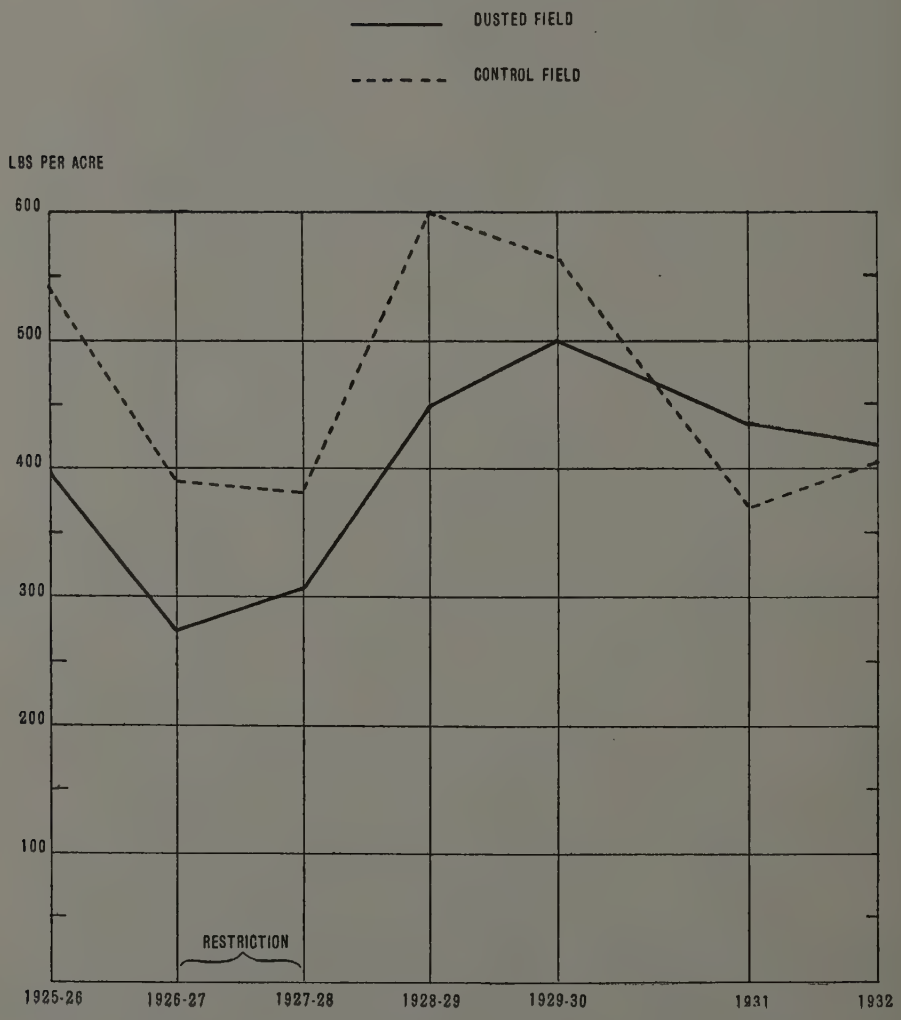
Monthly yields of plots (160 trees) in lb. dry rubber per 12 tappings

Month		Dusted Plots	Control Plots
March 1930	...	55·3	46·1
April	...	62·2	51·0
May	...	60·4	53·0
June	...	63·9	54·0
July	...	62·6	51·0
August	...	62·0	48·2
September	...	60·3	54·3
October	...	52·6	49·6
November	...	49·1	45·7
December	...	48·7	48·1
Total for 1930 (10 months)	...	577·1	501·0
January 1931	...	47·7	43·9
February	...	40·8	34·7
March	...	55·4	23·8
April	...	79·3	35·4
May	...	69·3	34·6
June	...	62·4	34·7
July	...	60·8	34·6
August	...	55·4	36·2
September	...	63·7	41·5
October	...	59·3	43·9
November	...	60·8	45·5
December	...	56·5	46·6
Total for 1931	...	711·4	455·4
January 1932	...	51·7	42·6
February	...	53·5	39·9
March	...	46·3	35·3
April	...	61·9	32·4
May	...	62·7	40·6
June	...	73·4	48·5
July	...	71·8	53·0
August	...	65·0	49·7
September	...	61·9	49·4
October	...	62·2	50·7
November	...	41·4	26·7
December	...	51·3	37·6
Total for 1932	...	703·1	506·4

Reference to Graph I will show that although the superior yield of the dusted field was maintained to some extent during 1932, the recovery in yield after wintering was slower than in

GRAPH-II

ANNUAL YIELDS PER ACRE



1931 when defoliation was more successfully prevented. The normal depression of yield during the months of January and February was prolonged by a further fall in March when the trees were suffering abnormal defoliation. The yield of the dusted field started to recover in April, and subsequently the monthly yields followed a very similar course in the two areas. In 1932, as in the previous year, there is a striking correlation between yield and condition of the foliage.

Table II gives the actual yields recorded and the average per tree per tapping for the three years 1930-32. The latter figure is the average yield, not of the trees in tapping, but of the total number of trees in the plots. The figure for number of tappings is not the total number of days in the year in which the trees were tapped, but the number on which the yield was recorded. Owing to the fact that the yields are recorded from measurements of latex, the dry rubber content being determined by weekly trial coagulations, no day is included on which rain falls before the latex reaches the factory.

Table II

	Total yield in lb.		No. of recorded tappings		Average yield per tree per tapping in ozs.	
Year	Dusted Plots	Control Plots	Dusted Plots	Control Plots	Dusted Plots	Control Plots
1930 March to December	591	513	123	123	·48	·41
1931	653	408	129	131	·51	·31
1932	560	388	114	111	·49	·35

The fall in yield of the control plots in 1931 has already been commented on. In 1932 the yield per tapping in the control field has increased from ·31 oz. to ·35 oz., while the similar figure in the dusted field has fallen slightly from ·51 oz. to ·49 oz. Since the intensity of the disease was as great in 1932 as in previous years it must be concluded that 1932 was a relatively favourable year for crop (as measured in the form of yield per tapping), and that the yield of the dusted field has fallen on account of the failure of the dusting operations.

Table III and Graph II express the same results in terms of yield per acre. The figures previous to 1931 are estate figures relating to the two fields in question, while those for 1931

and 1932 have been calculated from the experimental tappings and the known stand of trees per acre. It will be noted that although the yield of the dusted field has decreased and that of the control field has increased in 1932, the former is still greater than the latter, the reverse of the position in earlier years.

Table III

Yield per acre in lb. dry rubber

Year	1925-26	1926-27	1927-28	1928-29	1929-30	1931	1932
Dusted Field	397	272*	305*	449	499†	434	419
Control Field	541	391*	382*	600	564†	368	402

*Restricted Crop †10 Months' Tapping.

CONCLUSIONS

The yield records obtained in 1931 showed that the control of the disease obtained by sulphur dusting was accompanied by a comparative increase in yield, the biggest difference between the two fields being evidenced during the months in which there was the greatest contrast in the foliage. (See Rubber Research Scheme *Quarterly Circular* Vol. 8, Part 4.) The yields for 1932 offer confirmatory evidence of a negative character. As explained above successful control in the dusted field was not obtained, and this has been reflected in a decreased yield. It is to be noted that the yield of the control field, so far from showing a further decline, has actually recorded a substantial gain in 1932. There is no reason to emphasize this increase as it is probably a normal annual variation, but it lends greater significance to the small decrease in the dusted field. Despite this decrease, however, the yield per acre still remains higher in the dusted field than in the control, a reversal of the position in earlier years before control methods were adopted. The experience of 1932, therefore, indicates that although sulphur dusting cannot be neglected for any one year without detriment to the foliage and to the normal recovery in yield after wintering, the benefits to the general health of the trees conferred by previous years' treatment are to some extent cumulative.

ACKNOWLEDGMENTS

The courtesy of the Warriapolla Estates Company, Limited in permitting these experiments to be continued on their property, and the valuable co-operation of Mr. M. C. Evans, Superintendent of Kandanuwara Estate, are again gratefully acknowledged.

DISEASES OF RUBBER IN CEYLON, 1932

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1. FOREWORD

THIS article is the fourth of a series of annual reviews whose purpose is to keep planters in touch with recent developments regarding diseases and pests of rubber. During the greater part of 1932 the writer was away from the Island on home leave and therefore had little opportunity of making observations regarding the disease position and the current methods of control. It is considered desirable, however, to maintain the continuity of the series, and an account is given of any diseases of interest which came to the notice of the Research Scheme during the year.

2. ROOT AND COLLAR DISEASES

The necessity for making the utmost efforts to control the spread of *Fomes lignosus* even under present economic conditions has been stressed in previous reports. The disease caused by this fungus continues to be the most important on the majority of estates, and it is feared that if adequate control measures are not maintained it may in some instances assume such a serious aspect as to become a limiting factor in the yield of the estate.

There are indications that the presence of *Fomes lignosus* may also give rise to serious problems in replanting old areas. It would seem that in certain instances the fungus is lying dormant in the soil and that the culture, previously staled, becomes re-invigorated when replanting operations are undertaken. The question of removal from the soil of the old rubber roots and stumps offers an important line of investigation in connection with the parasitism of the fungus under various conditions.

Attack by *Ustulina zonata* on root, collar and stem is also important in wet districts and treatment should receive careful attention. Detection of fructifications in the early stages is the first necessity in the control of collar and stem infection, and this can only be done by periodical inspection.

3. STEM DISEASES

There are no new developments to report for 1932 in connection with stem diseases of mature trees.

On some estates which curtailed the usual preventive treatment on economic grounds, Bark Rot was relatively severe in the wet weather in the latter half of the year. In continuous wet weather it is usually impossible to make regular applications of greasy waterproof mixtures, and under such circumstances resource must be had to water-miscible disinfectants.

Brown Bast remains a serious factor in reducing yields in certain dry districts, but under present economic conditions treatment is not being carried out extensively.

4. LEAF DISEASES

It is satisfactory to note that despite the cessation of manuring and other cultivation measures defoliation due to *Phytophthora palmivora* was very slight. This was possibly due to the abnormal distribution of monsoon rains, for although the rainfall during the last five months of the year was unusually severe, June and July were exceptionally dry months.

As in former years *Oidium* caused defoliation of late wintering trees in most districts. The disease continues to be very severe at mid-country elevations where the fungus is favoured by relatively cool and dry atmospheric conditions, but in the main low-country districts it seems unlikely to assume a serious aspect. It is not impossible, however, that continued partial defoliation of a proportion of trees may ultimately lead to a decline in yield.

5. DISEASES IN BUDDED CLEARINGS

Two diseases of young budgrafts were investigated in the early part of the year.

(1) This was a die-back of young green shoots from the union and was observed on two estates in the Kalutara district and at the Experiment Station, Nivitigalakele, the age of the shoots being 1-6 months. In all the specimens examined *Diplodia* was present and was apparently responsible for the die-back up the shoots, entrance having been gained at or near the union. In some cases the tip of the shoot was also withered. The fungus was isolated in pure culture and inoculations made on wounded and unwounded green bud-shoots. From the fact that no infection occurred it was concluded that *Diplodia* was only secondarily responsible for the diseased condition, and it was necessary to determine the primary factor.

A careful study was made of all stages of the disease in the field. A longitudinal section at the union of affected plants showed in all cases an internal pad of coagulated latex at the junction of the shoot with the stock. It was concluded that this pad was caused by an internal fissure, a phenomenon which has been described in Java by Bobilioff. In all cases the shoot bore a very heavy head of foliage, and it seemed probable that excessive movement of the shoot in the wind, in conjunction with the internal fissure, caused a rupture at the union through which *Diplodia* gained entrance. The origin of these fissures is not known, but they are possibly connected with very rapid growth, and appear to occur more commonly in certain clones. It is significant that in all the specimens examined the stock was exceptionally large (3-5 years old), resulting in a very rapid growth of the bud-shoot. It is possible that under such circumstances unsatisfactory unions may be somewhat frequent. It would appear that clone B. D. 5 is particularly liable to the trouble, and it is also interesting to note that all the diseased shoots at Nivitigalakele were of one (Ceylon) clone. It is suggested that with buddings of apparently susceptible clones on very large stocks, one stock shoot should for some weeks be allowed to grow in addition to the bud-shoot so as to retard the early rate of growth of the latter.

(2) After the exceptional drought experienced in January and February a number of specimens was received in which the bark of 2-3 year-old buddings had died back near the union. A study of the disease on an estate in the Ratnapura district showed that the primary cause was sun-scorch, which had caused cracking of the bark on the raised portion of the "elephant foot". In most cases *Diplodia* had gained entrance through the cracked bark with consequent extension up the stem and into the wood. The old bud-shoots had shown no effects in the foliage as the result of this disease condition, but young green shoots were reported to have died back. There was no evidence of the fungus invasion having started from the stock snag, and in some instances the diseased portion was entirely separate from the snag. The plants could mostly be treated by excision of the diseased tissues.

Trouble is being commonly experienced with decay of the stock snag before callusing is completed, the rot often extending several inches down into the stock or up the scion. Where decay has occurred all rotted wood should be cleaned out with

a chisel, the surface painted with disinfectant, and the resulting cavity filled with a plastic mixture such as Colas and sand in the proportions 1:2. Prevention, however, is better than cure, and it should be the aim of those possessing young budded clearings to prevent the occurrence of this decay by ensuring rapid callus growth and protecting the snag with a satisfactory waterproof mixture. An application of manure prior to the final cutting of the stock is the best insurance against this trouble, but a great deal can also be done by correct treatment of the stock on the following lines:

The stock should be finally cut back to the point of union when the shoot is growing vigorously and has formed about 3 ft. of brown wood; the time of "desnagging" must not be delayed until the stock is already dead and discoloured at the point at which it is to be cut. A common mistake is to make the cut too flat; it should be made at an angle of at least 45°, this being particularly important with large stocks. The ideal material for applying to the cut stock has not yet been discovered, but satisfactory results are being obtained at the Rubber Research Scheme Experiment Station by painting with a 10% mixture in water of Brunolinum Plantarium, and applying a coating of Skene's pruning mixture on the following day. The snags should be periodically inspected until the callusing is complete, and the waterproof covering renewed if necessary. For a fuller account of the treatment of snags reference may be made to Rubber Research Scheme *Quarterly Circular*, Vol. 9, Parts 3 and 4.

It is of interest to record that a specimen was received of the tap root of a young rubber stump attacked by *Sclerotium Rolfsii*. This fungus, which has a very wide host range, has hitherto only been reported on the hypocotyl of germinating seeds, and on renewing bark.

6. DISEASES AND PESTS IN NURSERIES

Die-back of green shoots caused by *Phytophthora palmivora* has again been in evidence in budwood nurseries during wet weather. The statement in former reports that Clone B.D. 5 is particularly susceptible to this disease is confirmed by experience in 1932. Satisfactory control of the disease can be obtained by spraying with Bordeaux Mixture or a similar copper fungicide.

Other diseases and pests in nurseries do not call for special comment.

THE EFFECT OF EARTH-COWDUNG MIXTURES ON RENEWING BARK

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1. INTRODUCTION

THE practice of applying mixtures containing cow-dung and earth as basic substances to recently tapped bark at the time of annual or six-monthly change-over of the tapping panel has been widely adopted in Ceylon for many years. The claim by the advocates of this practice that the bark renewal is thereby benefited does not, however, appear to have been substantiated by any controlled experiments. An offer by Mr. A. D. Panton, Superintendent of Nivitigala Estate, Nivitigala, to co-operate in an experiment to shed light on this point was therefore readily accepted.

2. DETAILS OF EXPERIMENT

(a) *Experimental Area.*—A uniform field of well-grown mature rubber (1905 planting) was selected on Nivitigala Estate. Tapping had been stopped on the 31st May, 1931, for an indefinite period.

(b) *Treatments.*—Three mixtures were chosen which were thought to be representative of the types used on Ceylon estates. The composition of these mixtures is given below:

Treatment	A	B	C	D
Ant-hill earth	24 parts	14 parts	16 parts	CONTROL
Cow-dung (dry)	12 ,,	28 ,,	32 ,,	
Tallow	6 ,,	7 ,,	—	
Sulphur	3 ,,	—	—	
Copper Sulphate	1 ,,	—	—	
Lime	1 ,,	—	—	

Mixture A was prepared as follows: The ant-hill earth and dried cow-dung were thoroughly mixed and the sulphur added. The tallow was then melted and stirred in. The copper sulphate and lime were dissolved in enough water to make a thick paste of the whole mixture. Mixture B was prepared by mixing the earth and cow-dung, adding water to make a paste, and then working in the unmelted tallow which was broken down with the hands. The method of incorporating the tallow used for Mixture A was found to be the quicker, and probably ensures a more intimate mixture.

(c) *Arrangement of Plots.*—Each plot consisted of approximately 60 trees (10 × 6). Fourfold replication of each treatment (including the control) was adopted, giving a total of 16 plots. The plots were arranged in the form of a Latin Square as shown below. The special feature of a Latin Square is that each treatment occurs once in each column and once in each row, thereby allowing for elimination of soil differences by statistical methods in two directions, i.e., between columns and between rows.

A	B	C	D
C	D	A	B
B	C	D	A
D	A	B	C

In order to facilitate the identification of plots by the labourers applying the mixtures, the outside trees of each plot were painted with a broad ring, a colour being allotted to each treatment.

(d) *Application.*—Tapping was stopped on the 31st May 1931, but owing to incessant rain it was impossible to apply the mixtures until August. The applications were made on August 9th to 11th, under the personal supervision of the Superintendent. A heavy fall of rain following immediately afterwards necessitated a second application being made.

As noted below all mixtures were found to adhere satisfactorily.

3. RESULTS

The trees were examined by the junior author on the 15th to 17th August, 1932, i.e., one year after the mixtures were applied. A sample of renewing bark was taken from each tree one inch above the middle of the cut, and the thickness of each sample measured with a micrometer gauge to 1/100 millimetre. The mean thickness of renewing bark for the four treatments was as follows:

Treatment	A	B	C	D
Mean Thickness of Renewing Bark in mms.	3·52	3·48	3·34	3·44
Number of trees	205	200	216	187

A statistical examination of the detailed results shows that there is no significant difference between any of the treatments.

While taking the bark samples the outer corky layer together with the layer of cow-dung mixture became detached in most cases, and the above figures are therefore measurements of the live cortex only. In order to determine whether the application of the mixtures had resulted in any increased thickness of the outer layer all samples which retained this layer intact were measured with and without the outer bark. The mean figures for the difference i.e., the thickness of the outer bark only, are given below:

Treatment	A	B	C	D
Mean Thickness of Outer Bark in mms.	1·13	1·21	1·13	1·01
Number of trees	74	92	88	75

It will be seen that the figures for the treated bark are in all cases slightly higher than that for the control, but it is probable that most if not all of this difference (amounting to only about $\frac{1}{5}$—$\frac{1}{10}$ millimetre) was due to the thickness of the actual layer of mixture. In any case measurements of rough bark to this degree of accuracy are rather uncertain, and it must be concluded that no increased thickness due to the treatments is evident.

The adherence of all three mixtures was satisfactory, Mixtures A and B, containing tallow, being somewhat better in this respect than the mixture of earth and cow-dung alone. In the B and C plots a large number of panels had been stripped of the mixtures by termites, but Mixture A, containing various chemicals, was untouched.

4. CONCLUSIONS

This experiment shows that under the conditions obtaining on Nivitigala Estate during the period August, 1931, to August, 1932, the application of the mixtures concerned has not proved beneficial to the renewal of the recently tapped cortex, and this conclusion can probably be extended to embrace any other mixtures of a similar type. It would be rash, however, to conclude that under no circumstances will the application of such a mixture be of benefit. Any improvement in bark renewal as the result of such treatment would probably be due to partial shading of the inner cortex from strong sunlight. It is to be noted that unusually wet weather was experienced on Nivitigala Estate for some months after the applications were made, so that the renewing bark was seldom exposed to sunlight. It is possible that the treatment may be of benefit when carried out immediately before the wintering period or on estates where the foliage is sparse. Further experiments are needed to elucidate this point, but in the meantime it would appear that estates with normal foliage which employ a six-monthly change-over might omit the treatment when the cuts are changed in September.

5. ACKNOWLEDGMENT

Grateful acknowledgment is made to the Grand Central Rubber Estates, Ltd., for their permission to carry out this experiment, and to Mr. A. D. Panton, Superintendent of Nivitigala Estate, for his co-operation.

SOME OBSERVATIONS ON THE CITRUS INDUSTRY OF PALESTINE WITH REFERENCE TO APPLICATION OF IMPROVED METHODS*

AT the present time, Palestine has an area of roughly 120,000 donums or approximately 28,000 acres under citrus fruits, a considerable portion of which is not yet in full bearing. This season's export is estimated as being in the neighbourhood of 3,250,000 cases, more than twice that of South Africa, and it is anticipated that within a few years exports will have increased from 6,000,000 to 8,000,000 cases. It will thus be seen that in proportion to its size, Palestine produces more citrus fruits than any other country in the world.

The present season's prices are disastrously low, being now sometimes as small as 6s. to 7s. per case, which is from 3s. to 4s. below the cost of placing the fruit on the United Kingdom market. The present prices for citrus fruits in Roumania and in other markets is about at the same level.

The reasons for these low prices are in the main:

(*a*) heavy competition from Spain and the other Mediterranean countries;

(*b*) low standards of grading and packing, with the consequent exceptionally high percentage of wastage in transit.

Taking the industry from a general point of view, it appears that Cyprus has much less to learn from Palestine than was originally supposed, but there are, nevertheless, certain improved methods which might with advantage be applied to the industry here.

The change from the old to more modern methods of cultivation, nursery work, grading and packing, foretold by Prof. H. Clark Powell in 1928, was observed to be taking place slowly, and many problems still exist in Palestine, particularly those connected with grading and packing, which are very far from being solved.

In this report, it is proposed to deal with each phase of the industry in turn and to examine it, more particularly in regard to the application of any of the improved methods to the citrus industry in Cyprus, where conditions are, for the most part, similar to those obtaining in Palestine, as opposed to those existing in the more advanced citrus-growing countries of California, South Africa and Florida.

NURSERY WORK

Palestine is now gradually changing over from the time-honoured custom of budding stocks *in situ*. Many growers, particularly the Arabs, still employ the old system, but the modern system as employed in all other citrus-growing countries is making its appearance in many of the newer

* By B. J. Weston, B.A., M.Sc., F.R.H.S., Government Horticulturist, Cyprus, in Bulletin No. 1, July, 1932, (Horticultural Series) Department of Agriculture, Cyprus.

Jewish "colonies" and, of course, in demonstration plots of the various agricultural institutes. One particularly fine grove was inspected at the "Mikveh Israel Agricultural College," near Jaffa. The trees were five years old from planting and were carrying a very good commercial crop, two years before the time a commercial crop is normally borne by trees budded *in situ*. The trees were also of much better shape (from the point of view of picking, spraying, fumigating and crop carrying) than trees in the same station propagated by the old system.

Several nurseries are now being established by private persons in various parts of Palestine, which together with nurseries maintained by the Department of Agriculture and certain colleges pay special attention to bud and stock selection and the formation of mechanically strong trees. The Division of Horticulture of Palestine has, apparently, no hesitation in recommending the planting of budded trees rather than stocks, when new groves are being laid out.

STOCKS

Several different types of stock are being employed in Palestine, but the two chief ones are the Sweet Lime (*C. Aurantifolia*) and the Bitter or Sour Orange *C. Aurantium*), the former being used only on the lightest soils, owing to its extreme susceptibility to the various root diseases.

A very good example of the superiority of the "sour" stock was observed at Lord Melchett's estate, on the shores of the Sea of Galilee. There were two plantings alongside each other, one consisting of Jaffa oranges on Sweet Lime stock and the other of Jaffa oranges on Sour or Bitter Orange stock. The trees on Sweet Lime stock were 17 years old and the ones on Sour stock 15 years. The planting distance was about 20 feet in both cases, the "square" system being employed. The trees on Sweet Lime were showing considerable "die-back", many of them were infected with gummosis, they were not uniform, they were carrying only a fair crop and the fruit was of inferior flavour, whilst the trees on the Sour or Bitter Orange stock although two years younger were very much bigger, viz., had a larger potential bearing surface, free from disease, very uniform and well formed, and carrying a heavy crop of the highest quality fruit.

BUD SELECTION

Bud selection has not been practised to any great extent in Palestine in the past. The great importance of it, in view of the tendency of the Jaffa orange to "deteriorate," is now, however, beginning to be realized and is being carried out by some of the more enlightened growers. The Division of Horticulture has a system whereby the best trees in the various districts are recorded and made available for the distribution of budwood.

SYSTEMS OF TRAINING

Broadly speaking, two systems of training are practised, one by the Arabs and one by the Jews. Very high budding has been carried out in the past, but normal budding (from 6 to 8 inches) is now the rule with the more advanced growers.

The "Arab" system is very upright in its effect and produces a very tall and unwieldy tree; the Jewish system goes to the other extreme, and the tree is pruned and "skirted" so as to look almost like a formal ornamental shrub. Of the two, the Jewish system is much nearer the mark,

but an intermediate system is more desirable, and such a system should be followed in Cyprus. In nature, a well grown normal citrus tree assumes more or less a spherical shape, and there seems no particular reason for modifying this habit of growth, as a large percentage of the fruit is carried on the lower portion of the tree, and a "spherical" tree is much easier to deal with in the orchard.

As it is unlikely that a reliable private nursery will be established in Cyprus for some time to come, it appears desirable that the policy of producing a good type of nursery tree in the Nursery Gardens of this Department should be proceeded with, in these areas of the Island where citrus fruits are grown commercially, greater attention being paid to Stock and bud selection, training and individual care in the nursery.

PLANTING DISTANCE

The older groves in Palestine are very closely planted, but the evils of this system are now being realized and most of the modern plantings are made at 4 to 6 and even 7 metres, which greatly facilitates orchard operations of all kinds, and taken on an average probably does not reduce the yield per acre. Indeed cases have been observed where the removal of trees in a closely planted grove, so as to increase the planting distance to about 5½ to 6 metres has definitely increased the yield per acre, by the greatly increased yields of the remaining trees.

CULTIVATION, ETC.

Hand cultivation is still used in the older groves, as it would be impossible to use implements either with animal or mechanical power, but in the newer plantings mechanical cultivation is now being employed with success and the advantage of this system will be more felt as the cost of labour increases, as it is likely to do. The advantages of a wide planting distance in this connection have been mentioned previously.

The importance of green manuring crops has already been recognized in Palestine, Lupins, (*Lupinus* spp.) being frequently employed for this purpose. In Cyprus, where the soil is often deficient in organic constituents, the growth of green manuring crops is probably more important, especially on the very light soils in the Famagusta area, and the policy of growing suitable crops for the purpose of ploughing in should certainly be continued. In this connection, it may be noted that both the Experimental Citrus Station at Famagusta, and the Lime Plantation at Lapithos will be carrying crops of Vicos this year, for green manuring purposes.

In Palestine, as in Cyprus, most of the irrigation water comes from underground sources and is distributed throughout the groves mainly by concrete flumes. Applications of water are made every 10 to 14 days or at even shorter periods in Palestine, the basin system of irrigation being chiefly employed. This system is suitable for light soils and where the slope is too great for furrow irrigation, but water should not be allowed to come into contact with the trunks of the trees, as this is well known to be a contributory factor to the cause of the various gummosis diseases common, both in Cyprus and Palestine.

There are no recognized systems in regard to the use of fertilizers in Palestine but the majority of the growers use large quantities of organic manure and some use complete commercial fertilizers as well. The amounts of organic manure commonly used varies from 10 to 20 tons per acre. The Division of Horticulture of the Palestine Department of Agriculture is, at present, carrying out some investigations in regard to the use of fertilizers.

PESTS AND DISEASES

Insects

The most serious insect pest of citrus in Palestine appears to be Black Scale, *Chrysomphalus aonidum,* which is, however, as yet confined mainly to the north of the country. Every effort is being made to prevent it becoming established in the closely planted area in the Jaffa district, where it would be extremely difficult to control owing to the impossibility of successful fumigation or spraying. Government regulations prohibit the transport of citrus fruits from the north to the south of Palestine, and all cars are examined at a barrier placed across the main Haifa-Jerusalem road at Jenin, to see that no infected fruit passes into the southern area, which is at present almost free from Black Scale. Latterly, however, the insect has made its appearance in the Jaffa district, where its presence is causing much consternation.

I understand that, as far as is known, this scale does not exist in Cyprus. It was, however, observed to be a serious pest on bananas at Tiberias, and as this fruit is exported from Palestine to Cyprus, careful watch should be kept for it.

The other insect pests affecting the citrus industry of Palestine include Red Scale (*Chrysomphalus aurantii*), mussel scale (*Lepidosaphes pinnaeformis*), mealy bug (*Pseudococcus* spp.), the soft brown scale (*Lecanium hesperidum*) and the Mediterranean Fruit Fly (*Ceratitus capitata*).

The latter is normally only serious at the end of the shipping season, and the two former together with the black scale, already mentioned, appear to be the most important insect pests of citrus in Palestine.

DISEASES

The various gummosis diseases are the most serious in Palestine and this, in the past, has probably been largely due to the use of Sweet Lime as a stock and to improper irrigation in the closely planted groves. The use of *Aurantium* stock and careful irrigation should largely eliminate these as time goes on. A similar method of control, or rather prevention of these diseases should be employed in Cyprus.

The various fungi causing wastage are also a serious handicap to the industry in Palestine.

The diseases causing wastage have recently been investigated by Dr. Reichert of the Division of Plant Pathology, P. Z. E. Agricultural Experimental Station, Tel-Aviv. The annual wastage in shipments due to the above causes has been estimated to be responsible for a loss amounting to £50,000.

The incidence of "black rot" (*Diplodia natalensis*) is unusually severe in Palestine, and this disease is said to attack the fruit even in immature stages on the tree. Dr. Reichert has found that pruning away "die-back" is a considerable factor in the control of this disease and also advocates the "de-buttoning" of fruit for export.

This disease is undergoing investigation in Cyprus, but it is fortunately less serious here.

The other mould fungi (*Penicillium* spp.) which occur in Palestine in common with every other citrus producing country are well known to be approximately proportional in severity to quality of grading and packing.

The importance of preventing insect pests and diseases now serious in Palestine, but as yet not common in Cyprus from becoming established is self-evident, and need not be emphasized here.

GRADING AND PACKING

Contrary to expectation, very little packing by the machinery is being done. One mechanical grader was inspected on the estate of Mr. Tolkovsky, which consisted of modified onion grader, and this was doing fairly satisfactory work. The only other type of mechanical grader inspected was a machine imported from Florida by the Pardess Co-operative Association. These were stated to be the only two mechanical graders in the country.

The difficulty of grading the typically shaped "Shamooti" orange has by no means been solved, and the Florida grader referred to above was stated often to become blocked and to be unable to keep packers continually supplied with fruit. Grading by means of hand sizers is now being tried out, the same methods being employed as for deciduous fruit in the Western Cape, South Africa, but this system has a very serious disadvantage in its slowness of operation. It appears that a really suitable type of mechanical grader for the Jaffa (Shamooti) type of orange has yet to be invented.

Grading by eye is therefore resorted to, but this will never be thoroughly satisfactory because it is impossible to grade really accurately in this way.

FLOWERING, POLLINATION, AND NATURAL CROSSING IN RICE*

THE following article presents in outline the results of some five years' observations made during the course of improvement work with rice in the departmental stud plots at Yanco, in the Murrumbidgee Irrigation area and briefly compare these with similar observations made in other rice-growing countries. Literature dealing with rice is remarkable for the diversity of opinion expressed by workers with this crop on such aspects as time of flowering, relationship between glume dehiscence and pollination, extent of natural crossing, etc. Jones in his review of this literature, ascribes the varying behaviour of rice in different parts of the world to varying local conditions, and to varietal peculiarities. It may therefore be of interest to report observations made under growing conditions which, in one respect at least, are apparently unique.

One of the principal objectives of the observations at Yanco has been to determine the precise conditions under which artificial hybridisation could be effected with maximum success. The varieties chiefly used were Caloro, Colusa, Carolina Gold, Carolina White, and Lady Wright. The first two are typical Japanese medium long-grained varieties, while the Carolinas and Lady Wright represent the long-grained types. Pure strains of these varieties were used, classified as follows regarding time taken to mature.

Early	Mid-season	Late	Very Late
175-180 days	180-185 days	185-190 days	190-195 days
Colusa Y180	Caloro Y316	Caloro Y46, Carolina White, Lady Wright	Carolina Gold

FLOWERING

Jones cites observations by many workers, and times of maximum flowering ranging from 8-9 a.m. in Burma (Thompstone) to 12-2 p.m. in California (Jones). The earliest and latest hours range from 5 a.m. in India (Ramiah) to 4 p.m. in California (Jones) and Texas (Laude and Stansel). Minimum temperatures of flowering are given ranging from 59°F. in northern Japan (Akemine) to 77°F. in different parts of India (Bhide, Ramiah, Rao). Of the writers cited by Jones comparatively few give temperatures at which maximum flowering occurs; most according to Jones, merely stating times. Ramiah is quoted as specifying 82° to 84°F., time varying in India; Kobayasi 86° ± 3·6°F. in Japan, while Akemine, also in Japan but working with a different variety of Kobayasi, specifies 95° to 104°F. as optimum.

* By W. Poggendorff, B.Sc. Agric., Assistant Plant Breeder in "*The Agricultural Gazette*" of New South Wales, Vol. XLIII, Part 12, December, 1932.

Noguti (formerly Kobayasi) alone is quoted as giving the relationships of both temperature and humidity to flowering. This worker, who appears to have made a most comprehensive study of the subject, in a translation of the original paper, states that flowering takes place when the temperature at 8 a.m. amounts to about 80° to 83°F., increasing in activity up to 90°F., almost ceasing above this temperature, with 122°F. as maximum limit. Some of these observations were made in a thermostat; 70 to 80 per cent. is given as the most favourable degree of moisture, and the sudden change in humidity in the morning is said to be soon followed by the main flowering period. Below 70 per cent. moisture the number of florets opening is diminished, but flowering occurs even at 50 per cent., though rarely below 65 per cent. The temperature given, 86° ± 3·6°F., is said to be the optimum for flowering if the air moisture is below 70 per cent.

At Yanco rice has not been observed to commence flowering at a temperature below 72°F., humidity 62 per cent. It has been found that, in general, the lower the humidity the higher the temperature required to initiate flowering. Thus, with a humidity of 32 per cent., the temperature required was 81°F. Optimum conditions for flowering at Yanco appear to be a temperature of 85° to 90°F. and a humidity of 55 to 70 per cent. This humidity is lower than that given by Noguti (or Noguchi), but the temperatures are similar. No varietal differences have been observed—the conditions which initiated flowering in any one variety have invariably brought it about in others at the same stage of development.

The maximum temperature and humidity for flowering have not yet been accurately determined at Yanco because by the time the temperature has risen to any high value in the field, the supply of florets ready to open has usually become exhausted. The highest temperature observed at which flowering occurs is 102°F., humidity 60 per cent., but there is no reason to suppose this the limit.

The time of day at which flowering commences varies very widely, according to weather conditions; on a bright clear day, with little or no wind, it usually commences between 8 and 9 a.m., reaches a maximum between 11-30 and 12-30 p.m., and ceases between 3 and 4 p.m. It has, however, been observed to occur at 6 a.m., with the maximum period between 9 and 10 a.m., and as late as 5-30 p.m. Wind and cloud, if slight, have the effect of postponing flowering, and if marked, can prevent it entirely; rain has a similar but more severe effect, in contrast to Noguti's experience in Japan. The amount-of-flowering curve follows the humidity curve with remarkable fidelity, but with a slight time-lag, as though the actual *variation* in humidity were an important factor.

Considerable evidence, which it is hoped to present in detail in a later article, is accumulating to indicate that between temperatures of 72° and 100°F. (and probably higher) humidity plays the principal part in determining the amount of flowering, and that other relevent factors act through humidity. For instance, wind arising while flowering is in progress has usually had a restricting effect, even though the temperature has risen.

POLLINATION

From a review of the literature, Jones concludes that pollination just before or at the moment the flowers open is most usual, with comparatively rare cases in India (Bhide, Parnell, Parthasarathy) of pollination of some florets on a panicle after opening. This is also found to be the normal state of affairs at Yanco. Usually, in florets due to open on a given day, the anthers occupy a position about half-way up the glumes (in a short-glumed variety like Caloro, relatively less in a long-grained variety) in the early morning of that day. When suitable temperature and humidity are reached the anthers can be seen approaching the apex of the glumes, the time taken from the half-way position to reach one nearly touching the apex varying from thirty minutes at temperatures in the vicinity of 75°F., and comparatively high humidity, to two minutes or even less at about 90°F. humidity about 50 per cent. When the anthers almost touch the apex the glumes suddenly dehisce and spring apart as though under tension, their inner edges forming an initial angle of about 10 degrees. The tension appears to be provided by the lodicules which as Akemine, according to Jones, reports, have swollen to about three times their former size at this stage. Through the opening thus made the anthers immediately commence to protrude.

At this stage three types of pollination can be distinguished.

1. The anthers have burst, and pollination has taken place. This is comparatively rare at Yanco; it has been observed only when the temperature is high (in the vicinity of 95°F.), and the humidity low (30 to 40 per cent.), which set of conditions has occurred usually only late in the afternoon, towards the close of the flowering period, when a steady hot dry westerly wind has arisen.

2. Anthers burst as they emerge, or within a few seconds, and pollination follows as the glumes continue separating. This is the most usual occurrence throughout the season and during the daily maximum flowering period with all varieties. The observed temperature range is 80° to 100°F., humidity 45 to 50 per cent.

3. At temperatures between 72° and 90°F. with humidity over 60 per cent., and particularly when the humidity has fallen steeply from a high value just prior to flowering while the temperature has risen, the anthers emerge unbroken even damp. These conditions are comparatively rare at Yanco, occurring for any noteworthy period only on infrequent dull hot days, but more often for a short period in the mornings, about the commencement of the flowering period.

The filaments elongate rapidly, carrying the anthers out of the flower; practically erect at first, the weight of the anthers bends the filaments over between the separating glumes. The anthers commence to dehisce at some stage in this process; in extreme, but not infrequent cases, they are quite clear, and below the level of the floret. Pollen, in this case, is then very unlikely to fall on the stigmas of the same floret.

These three types are not clearly defined, but merge into one another. For instance, it happens sometimes that one set of three anthers bursts at emergence, the other triplet a few seconds later, when quite emerged. The actual dehiscence of the anthers is not violent; it commences at the

basal end, and pollen spills out gently as the split extends along the anther. A slight change occurs in colour as the anthers mature, from a light yellow at the "half-way position" (previously green) to a pale-cream, almost white, the colour of the ripe pollen. The angle between the glumes, in the meantime, gradually increases to about 30 degrees, very slowly towards the end, the total time occupied being about 60 to 180 seconds. Fruwirth is reported by Hayes and Garber to specify 30 seconds, while Copeland reports Mendiola has given 6·5 to 6·9 minutes in the Philippines. The feathery stigmas gradually curve over, one to each side, and protrude in the angle between the glumes, covering the lodicules; they are usually slightly moist from the time they first become visible in the usual course of events pollen falls thickly on the stigmas; in a few minutes this pollen changes colour from a pale-cream to golden, even to a slightly orange tint, probably owing to absorption of moisture from the stigmatic surface and germination.

The flower remains open for a time varying from 13 to 75 minutes; this time, also, appears to be governed by the relative humidity of the air—the time is shorter at low humidity, and longer at high. The effect is probably due to desiccation of the lodicules, resulting in gradual slackening of the tension holding the glumes apart. Mendiola gives the time the florets remain open as fifteen minutes to two hours in the Philippines, Chiapelli one to two hours in Italy, Akemine, according to Jones, one and a half to two and a half hours in Japan. The glumes gradually close, pinching the flaccid filaments, and usually the withered or withering stigmas, one on each side, between them; these are not immediately severed, however, but usually persist for some time before falling. The glume edges do not interlock again until some hours after the floret has closed, usually the following night, when (and only if) the fertilised ovary has commenced to swell.

Pollination has not been observed to occur without opening of the floret, though Mendiola and Jones, reviewing observations in the Philippines, Java, India, and Italy state that closed pollination (cleistogamy) occurs in some varieties.

There is some difference in pollination among the varieties observed: the tendency of florets to open without immediate dehiscence of the anthers is more marked in long-grained varieties, because the distance the anthers have to be carried before reaching the apex of the glumes is greater, and in the meantime these have possibly opened. The sudden dehiscence of the glumes may be a means of bursting the ripe anthers, which are probably less susceptible to shock when not in close contact with the apex.

NATURAL CROSSING

Jones, in concluding his review of literature on natural crossing, states: "..... natural crossing in rice ranges from practically none in Hawaii and California to as high as 23 per cent. in Java. Climatic conditions appear to have a marked effect upon the extent of natural crossing. In Japan and Java high humidity and low temperatures seem to favour natural crossing, while low humidity and high temperature are more favourable for auto-fecundation. The extent of natural crossing in rice also depends upon the peculiarities of the variety grown, as was observed in Japan and Java. Other external factors which influence the extent of natural crossing in rice are wind velocity, rain, and insects of various kinds which visit the florets while in bloom".

Mendiola states that natural hybrids are being continually produced in the Philippines, and ascribes to the effects of natural crossing the unsteady yield performance of different supposedly pure lines. Jones reports Ikeno, in Japan, as concluding that "crossing is very rare in nature," while Hoshino, quoting Kato, also in Japan, states that natural crossing often occurs.

The great importance of natural crossing in accounting for the very numerous varieties of rice grown in the world, often many in one small district, and the constant occurrence of variations in commercial crops has been stressed by many writers. As a source of new varieties Mendiola refers to natural crossing as "both the hope and despair of the rice breeder".

Natural crossing is known to occur at Yanco:

1. By the repeated discovery in supposedly pure lines growing in the stud plots, of variant types whose subsequent behaviour has shown them to be unfixed crossbreds.

2. By the diversity of types encountered in field crops, originally apparently homogeneous. To take a specific instance, by the rapid increase in the percentage of red rice in one variety, Colusa. The proportion increased from about ·05 per cent. in 1926 to nearly 6·5 per cent. in 1930, when the variety was withdrawn from cultivation. Natural crossing must be invoked as an explanation, keeping in mind the Mendelian dominance of the red grain factor for possible increase due to earlier ripening and shattering of a red-grained variety present as admixture will not hold, as weeds do not usually permit the growing of rice in two successive seasons on the same land.

3. By experiments carried out in the stud plots with varieties of similar maturity differing in some marked character. Caloro Y46 was grown in a row spaced 2 links (40 cm.) from a late red-grained selection in 1930. Of 2,017 plants grown from seed from the Caloro Y46 row in 1931, nine were red-grained, equalling 0·044 per cent. natural crossing. Segregation counts in 1932 showed the particular red-grain factor involved to be a simple Mendelian dominant. The rate of natural crossing is probably much higher under field conditions, where rice is drilled in 7 inches (13·5 cm.) apart and plants touch one another in the drills. Further experiments are under way to determine this point, also to ascertain the maximum distance over which natural crossing can be expected to occur.

Temperature and humidity are certainly important factors influencing pollination, as pointed out under the previous headings "Flowering" and "Pollination", and therefore natural crossing. Wind is important as a ready means of conveying pollen over very considerable distances. Mendiola gives a table showing the distances wind-borne pollen will travel at various wind velocities. He considers 6·5 feet (2 m.) apart a safe distance for sowing rows of different varieties to avoid natural crossing. Bees are frequent visitors to rice in bloom. I am indebted to Mr. C. P. Hely, Departmental Entomologist on the Area, for identification of the following insects observed in association with rice heads in bloom: Honey Bee (*Apis mellifica*), Pumpkin Beetle (*Aulacophora olivierii*), Black Flea Beetle (*Haltica ignea*), Rice Beetle (*Laius femoralis*).

SUMMARY

Flowering

1. Temperature and humidity are closely interrelated in governing flowering, and, within limits, in inverse ratio.

2. The minimum temperature at which flowering occurs is 72°F. if the humidity is not less than 62 per cent.

3. Maximum flowering occurs when the temperature is 85° to 90°F., and humidity 55 to 70 per cent.

4. The highest temperature at which flowering has been observed to occur is 102°F., humidity 60 per cent.

5. The response of all varieties observed to a given set of conditions was the same.

6. The time of flowering varies with weather conditions; it usually commences at 8-30 a.m., reaches a maximum between 11-30 a.m. and 12-30 p.m., and ceases about 3-30 p.m.

7. Observed extremes in flowering time are 6 a.m. and 5-30 p.m.

8. Wind, clouds and rain adversely affect flowering.

9. Relative humidity is the most important factor governing the amount of flowering between temperatures of 72° and 100°F. The variation of humidity appears to play some part.

10. The normal humidity during the flowering period of rice is unusually low at Yanco in comparison with published data for other countries.

POLLINATION

1. Three types of pollination occur—

   (a) Before the florets open—when the temperature is high (about 95°F.) and humidity low (about 35 per cent.); rare.

   (b) At opening of the florets, or within a few seconds—when the temperature is 80° to 100°F., and humidity 45 to 50 per cent.; usual

   (c) After the florets have opened—when the temperature is between 72° and 90°F., and humidity high (over 60 per cent.); not infrequent.

2. The glumes open to a maximum angle of about 30 degrees in from one to three minutes, and remain open for thirteen to seventy-five minutes. This time is apparently governed by the relative humidity of the air.

3. Cleistogamy has not been observed to occur.

4. Pollination is more likely to occur after, rather than at, opening of the florets in long-glumed varieties than in short-glumed varieties.

NATURAL CROSSING

1. Natural crossing is known to occur at Yanco—

   (a) By the discovery of occasional heterozygotes in supposedly pure lines.

   (b) By the diversity of variant types increasingly occurring in commercial crops.

   (c) By experiment in the stud plots; 0·044 per cent. natural crossing observed at 2 links (40 cm.).

2. In addition to temperature and humidity, wind is an important factor.

3. A list is given of insects observed in association with rice in bloom.

TOBACCO-CURING BARNS*

WITH the approach of the tobacco harvesting season the question of curing the leaf will already be exercising the minds of growers. Any makeshift building will not answer the purpose, particularly if the grower intends to flue-cure his leaf. The wise grower, therefore, will need to make his plans immediately for the erection of an efficient barn if there is not already one on the property. Working-size plans of the flue-curing barn can be had on loan from the Department; also plan of the furnace used for heating the barn.

Flue-curing barns must be draught-proof and so finished that heat and moisture cannot escape, and they must be erected of materials, that will prevent the interior from being influenced to any great extent by outside temperatures. If iron is used double walls will be necessary in order to obtain the necessary degree of insulation. A brick structure, on the other hand, is expensive. Wood, pisé, fibro, and similar materials are some of the most suitable materials for tobacco-curing barns.

In order that a grower might have some idea of the size of the barn he requires, it is mentioned that the inside dimensions of a barn suitable to cure the crop from 6 or 7 acres would be 16 feet by 16 feet and 17 feet high, with a spacing of 3 feet 6 inches vertically between the tiers on which the sticks of tobacco are hung when harvested on the stalk, and 2 feet when the leaves have been "primed".

FLUE-CURING DESCRIBED

Whilst on the subject of curing-barns, a description of what is involved in the actual curing of the leaf will help to emphasise the importance of an efficient barn.

At the outset it is pointed out that whilst much good leaf is often spoilt by improper curing, it is not possible to make good tobacco out of poor leaf even by employing the best known curing methods. The first essential to success, therefore, is leaf harvested at the correct stage of maturity.

There are three stages in curing. They may be stated as follows: (1) yellowing, (2) fixing, (3) killing. No fixed formula can be given, but if the following is taken as a basis the grower will, after curing a few barns, be able to modify or vary the process in some respects to give him the desired results.

As soon as the barn is full, close the building right up, start the fire going, and bring the temperature up to 90°F. Keep it at this point for eighteen to thirty-six hours, according to the condition of the leaf, limiting the time to the shorter period in the case of leaf that is quite ripe, and allowing the full period where the leaf is not so well matured. If the leaf

* By C. J. Tregenna, Tobacco Expert in "*The Agricultural Gazette*" of New South Wales, Vol. XLIV, Part 2, February, 1933.

is not yellowing as it should, place sacks on the floor and soak them with water to produce a moist heat; or, better still, if a boiler is handy introduce steam. When the leaves have assumed a nice yellowish colour raise the temperature to 100 degrees, at the rate of 5 degrees each two hours, and keep at this figure for some six hours. Then raise the temperature to 105 degrees and give a little ventilation top and bottom, opening the ventilators a few inches. In these directions it is presumed that the curing-room is one that has been erected in accordance with the plans supplied by the Department of Agriculture. In such a building both temperature and ventilation could be controlled so as to produce the results desired.

Having obtained the temperature of 105 degrees with the limited ventilation mentioned, the conditions should be maintained for three or four hours. Then increase the temperature to 110 degrees, and also increase the ventilation to about one half of the capacity of the ventilators, and hold at that for three hours. Do not raise the temperature above 110 degrees until the tips of the leaves have dried, however. Next, again raise the temperature to 115 degrees for 6 hours, giving *full* ventilation, and then again advance to 120 degrees for six hours with full ventilation. The most critical time is between 110 degrees and 120 degrees. If the heat is too fast the leaf will splotch or blister, and if too slow it will sponge. When the sweat can be observed on the leaf, and it will not go off at once, the temperature must be increased rapidly by 10 degrees, and all available ventilation given; but if ventilation is given as directed there is little fear of sponging.

After remaining at 120 degrees for six hours, leave the ventilation at full, and increase the temperature by 5 degrees every two hours to 135 degrees; beyond this do not further increase the temperature until the blade of the leaf has dried out completely. Then exhaust all moisture by raising the temperature every hour by 5 degrees to 180 degrees, and gradually decrease the ventilation until only a very little is left at the top. Keep at the latter temperature until the stems and stalks have completely dried out. Ventilation plays a *most important part* in successful flue-curing during the stage from 105 to 140 degrees, and growers should pay particular attention to this matter. The whole process will take five or six days.

Extinguish the fire as soon as the tobacco is cured, and open the doors and ventilators to cool it off for twenty-four hours. If the weather be very dry, the moisture content of the barn may be increased with the aid of steam, or by means of water thrown on sacks on the barn floor. When the tobacco is in a condition to handle without the leaves breaking, it should be taken down on the sticks and bulked until the grower is ready to grade and bale for market as opportunity occurs.

SALINE AND ALKALINE SOILS*

THE development and application of new means for examining soils (such as precise procedures for measuring soil alkalinity, soil salinity, and exchangeable or surface-combined bases), has elucidated many of the difficult problems associated with the amelioration of infertile saline and alkaline soils, and has almost revolutionised ideas concerning their mode of formation and chemical relationships. The researches of Russian pedologists have added greatly to our knowledge of the natural history and field characters of these soils, while the laboratory studies of American soil scientists notably those of the California and Arizona Colleges of Agriculture, have done much to explain their chemical properties and behaviour under different treatments. Some of the more important results of these investigations will be considered in their chemical and agricultural aspects in this article.

I. DISTRIBUTION

Saline and alkaline soils are widely distributed in the arid tropics and sub-tropics. They occur wide-spread but are somewhat localised in the South-Western United States of America; Mexico; the Pacific slopes of South America; the western parts of Brazil and Argentina; North and South-West Africa (Sahara, Egypt, Sudan, Kalahari); Central and South-Western Asia (Arabia, Iraq, Persia, Palestine, Afghanistan, Baluchistan and Turkestan), the *reh* lands of India (Rajputana and Punjab); Central and Western Australia and in numerous smaller areas in other parts of the world, including certain West Indies Islands (Cuba, Haiti, Puerto Rico, Jamaica, St. Croix and Antigua). Their reclamation offers some of the most difficult problems that agriculturists have to face.

II. CLASSIFICATION, CHIEF FEATURES AND INTER-RELATIONSHIPS

The researches of Russian pedologists have led to the recognition of three main classes of arid soils, namely (a) Solontshak (saline soils; "white alkali" soils), (b) Solonetz; (alkaline soils; "black alkali" soils), and (c) Soloti (degraded alkaline soils). A fourth group, (d) Rendzinas, may be added to include alkaline non-saline soils rich in calcium carbonate.

(a) *Solontshak.*—This title is given to soils that contain large amounts of common salt (sodium chloride), whose presence may be attributed to inundation by sea-water, to decomposition of soda-bearing minerals, or to infiltration from strata rich in salt. They frequently also contain sodium sulphate and magnesium salts. Under dry conditions, salts may accumulate as a white surface efflorescence, but under wet conditions, the soils may exhibit a high water-table, and thus resemble salt-marsh soils, whose lack of aeration produces characteristic rusty mottling in the lower layers of the

* A Summary of Some Results of Recent Researches on their Origin, Genesis and Agricultural Relationships. By F. Hardy, in *Tropical Agriculture,* Vol. X, No. 2, February, 1933.

soil-profile. Saline soils are usually very permeable to water, owing to the flocculating effect of salts in solution. They are infertile for most crops, but may support a characteristic natural halophyte flora.

(b) *Solonetz.*—When solontshak is subjected to the leaching action of rain or irrigation water containing no salts, profound changes occur, but the final result is largely decided by the presence of calcium carbonate in the soil. Highly acidic, lime-free Solontshak soils, when leached, merely lose salts; there is little tendency for sodium-ion to replace hydrogen-ion in the original soil hydrogen-clay, so that the leached soil is still acidic. Calcareous soils which possess medium or low lime reserves, on the other hand, contain much lesser amounts of combined hydrogen-ion; their exchangeable bases consists mainly of calcium-ion, which in extreme cases, may almost saturate the clay fraction. Under these circumstances, sodium-ion, derived from sodium salts, may displace calcium-iron, and the resulting soils, after the leaching with pure water has removed salt excess, will consist chiefly of "sodium-clay". Sodium clay is notoriously sticky and cohesive, and the leached soils are difficult to till, compact, impermeable to water, and hard to drain; they "run together" when wetted, and the surface dries into a hard layer or pan. Such soils are generally infertile and agriculturally useless.

Furthermore, sodium-clay hydrolyses in the presence of water, giving sodium hydroxide, which imparts a high degree of alkalinity to the soil water. Thus, reaction values between pH 9·0 and pH 10·0 may be realized in calcareous saline soils that have been leached by pure water. During leaching, soluable chlorides disappear first, then sulphates, and finally, if it be present, calcium bicarbonate. This last may combine with sodium hydroxide, generated by hydrolysis of sodium-clay, to produce sodium carbonate ("black alkali") and sodium bicarbonate.

Whereas the soil-profile of Solontshak soils is uniform in appearance, that of Solonetz soils is characteristically stratified. The surface layer, containing the bulk of the soil organic matter, is finely laminated, and the underlying layer is crumbly and cloddy. The sub-soil is brownish-grey in colour, very hard and impervious, and exhibits a vertically-cracked columnar or prismatic structure. It contains alkali-soluble humus and sesquioxides, leached down from the surface soil layer, together with deeper-seated accumulations of calcium carbonate, calcium sulphate (gypsum), and various sodium salts.

(c) *Soloti.*—Further profound leaching of Solonetz soils, especially those containing appreciable lime reserves, removes all soluble salts, and eventually brings about the replacement of sodium-ion, combined in sodium-clay by calcium-ion. The physical properties of the soil are thereby greatly improved, for "calcium-clay" is not sticky, but tractable, permeable, free-draining, open, friable and crumbly. The reaction becomes less alkaline (pH 8·4 or below), and the soil is usually very fertile for many crops. Solonetz soils containing smaller lime reserves may gradually become acidic under continued leaching by water containing carbon-dioxide—combined calcium-ion being progressively replaced by hydrogen-ion. The displaced calcium-ion may first accumulate as concretionary calcium carbonate in the lower soil-layers. The soil-profile at this stage may resemble that of "black earth" (Tschernosem), characteristic of steppe and prairie country. Later,

the lime entirely disappears, and the soil becomes "degraded" into an acidic soil type, in which sesquioxides accumulate in the lower layers. Eventually, the sub-surface soil consists of residual silica, bleached white through loss of iron oxides, highly acidic in reaction, and infertile to crops. Such highly leached soils display a profile which, in extreme cases, resembles that of Podsol, a characteritic soil-type of humid climatic regions.

(d) *Rendzinas.*—These fertile, highly calcareous, non-saline soils exhibit a typical black, humic surface-layer of varying thickness, merging suddenly, through a more or less definite grey or pale-brown transition-layer, with the underlying whitish parent rock (limestone, coral or marl). The surface soil is often heavy and plastic; leaching may have removed much calcium carbonate, so that the reaction may be well below pH 8·4, which represents the degree of alkalinity of a saturated solution of calcium carbonate in carbolic acid.

Continued leaching may change black Rendzina to red "Terra Rossa" soil, as in the uplands of Cuba and Barbados. Typical Terra Rossa occurs in the Mediterranean region; its surface soil is usually acidic.

III. AGRICULTURAL RELATIONSHIPS OF SALINE AND ALKALINE SOILS

Much recent research has been directed to an elucidation of the reasons why saline and alkaline soils are so infertile and unproductive, and to means of ameliorating this condition by schemes of reclamation. Formerly, the infertility of these soils was attributed solely to the direct toxic effects on plant-growth of the various salts in solution. It is nowadays realized that moist soil is not simply a mixture of water and inert solid matter, but that the two components interact in a very complicated manner, giving products whose properties and composition depend upon the relative amounts of the interacting components, as well as upon their chemical constitution. A study of the practical significance of this generalisation involves several more or less distinct aspects, which perhaps may best be considered individually.

1 REACTION AND CONCENTRATION RELATIONS

When alkaline soils are treated in the laboratory with water, the degree of alkalinity developed depends on the extent of the dilution. Thus an extract prepared by mixing one part of soil with one part of water may show a pH value 8·60, but with 20 parts of water, the pH value may rise to pH 9·42, and with 160 parts of water, to pH 8·98. The difference between the first two values represents a seven-fold increase in alkalinity, due entirely to greater soil dilution and hydrolysis. On the other hand, dilution merely lowers the concentration of salts such as sodium chloride in saline soils, and thus renders them less harmless to plants. Hence the behaviour of saline and alkaline soils depends upon their degree of moistness in the field. Under wet conditions, alkalinity becomes enhanced, but salinity is much decreased, whilst under dry conditions, alkalinity is somewhat diminished, but salinity may attain highly injurious concentrations. The height of the water-table level in saline and alkaline soils is therefore an important factor in their agricultural relationships. It should be given careful consideration when alkali soils are irrigated, for irrigation may raise the water-table and thus increase the alkalinity of the surface soil, or bring up salts from the sub-soil.

2 CARBON-DIOXIDE RELATIONS

In our discussion of the chemistry of saline and alkaline soils, it was noted that the first alkali to appear when saline soils are changed into alkali soils by prolonged leaching, is sodium hydroxide, generated by hydrolysis of "sodium-clay". In the presence of excess of carbon-dioxide, sodium hydroxide becomes converted into sodium carbonate, and finally into sodium bicarbonate. These salts (particularly the latter) are much less alkaline than sodium hydroxide so that carbon dioxide acts as an alkali corrector. Thus, about three times as much sodium carbonate, and great many times as much sodium bicarbonate, than sodium hydroxide are required to give an alkalinity of pH 8·65 to their solutions in water. The fixation of alkali as sodium carbonates depends on the carbon dioxide concentration of the localised soil atmosphere and this in turn, depends partly on the quantity of soil organic matter that is undergoing oxidation through the activity of certain soil bacteria. Addition of bulky organic manures and green dressings to alkaline soils should therefore effect beneficial changes. Practical experience amply supports this contention, and organic manures are invariably advocated nowadays for ameliorating alkaline soils. Substances other than carbon-dioxide, however, may serve to reduce soil alkalinity by direct neutralisation. Thus, good results have been obtained by adding powdered sulphur at the rate of 2,000 to 4,000 pounds per acre. The sulphur becomes oxidised into sulphuric acid under the influence of certain soil bacteria. Ferrous sulphate and aluminium sulphate liberate free sulphuric acid when hydrolysed by water they too often give good results in ameliorating alkali-land. Finally, ammonium sulphate, used as nitrogenous manure, interacts with "black alkali" to form less harmful sodium sulphate, and is therefore sometimes preferable to sodium nitrate in the nitrogenous manuring of alkaline soils, including both Solonetz and non-saline calcareous soils (Rendzina).

3 EFFECT OF GYPSUM ON ALKALINE SOILS

The application of gypsum (calcium sulphate)—another corrective for soil alkali—is also well-established practice. The treatment was first advocated in 1888 by Hilgard, who attributed its effect to interaction with sodium carbonate, whereby calcium carbonate and sodium sulphate are formed, so that soluble alkali is replaced by a soluble neutral salt, and thus rendered innocuous. Gypsum is not always effective, however, in reducing soil alkalinity, and it has been shown that, in the absence of carbon-dioxide, gypsum-treated black alkali soil always contains an appreciable undecomposed residue of sodium carbonate. Hence gypsum should be accompanied by organic manures or by sulphur if successful results are to be obtained. Where the soil contains excessive amounts of salts, gypsum has little effect until the salts have first been removed by thorough leaching.

The modern view regarding the action of gypsum on alkaline soils, is that an excess of calcium-ions, derived from this or some other soluble calcium compound, first displaces sodium-ion from sodium-clay, thus rendering the soil more permeable. The liberated sodium-ions and the residual sulphate-ions are then easily leached by watering. Traces of sodium carbonate that may be present in the original alkali soil are not affected by this reaction, so that some other agent (such as carbon-dioxide derived from organic manures) must also be brought into operation in order to produce a neutral

soil. In theory, any soluble calcium salt would serve to effect base exchange, but only the cheapest can be used in practice. Green manuring greatly enhances alkaline-soil improvement by opening up the sub-soil by root penetration. Certain green manure crops, such as lucerne, and *Melilotus alba, Panicum crus-galli, Cynodon dactylon* (Bahama Grass), and other grasses, can tolerate considerable amounts of alkali, and are useful for this purpose.

4 PERMEABILITY OF SALINE AND ALKALINE SOILS

The great difference in permeability between sodium-clay and calcium-clay has already been mentioned. Since the success of irrigation for reclaiming alkali lands depends mainly on the ability of the soil to "take water", the question of soil permeability in relation to the proportionate amount of exchangeable sodium and calcium present has naturally received considerable attention from alkaline-soil investigators. Thus, attempts have been made to establish mathematical expression of this relationship, (Ca/Na Ratio) so that farmers might predict therefrom the behaviour of any soil whose exchangeable-base content has been experimentally determined. Unfortunately, the results obtained have proved disappointing. The following data, obtained by the writer for certain Antiguan soils, suitably illustrate this discrepancy.

Soil (Top 6 inch layer)	Exchange Capacity (mg. equivs.)	CaCO Content (%)	Ratio Ca/Na.	Capillary Rise in tubes of soil (cm. in 5 hrs.)
(1) Green-castle 1	15·4	0·0	91·8	11·2 c.m.
(2) Cedar Valley 2	27·1	39·6	76·6	14·8
(3) Collin's 3	24·1	5·9	22·2	12·5
(4) Paynter's 1	26·1	0·6	18·1	3·8
(5) Elliot's 1	28·2	6·7	10·4	1·8
(6) Cassada Garden 1	30·9	1·0	2·3	0·1

Whilst a general diminution in rate of capillary rise of water as the Ca/Na Ratio decreases is indicated by these data the relationship is not proportionate nor precise. Other factors, such as initial moisture content, calcium carbonate content, and degree of clayiness, are also involved. Moisture content in the field affects the Ca/Na Ratio markedly. Thus the ratio decreases as the soil loses water; a perfectly dry alkaline soil is extremely hard and highly dispersed. On the other hand, thorough leaching (if such can be properly accomplished) increases the Ca/Na Ratio by removing sodium-ion through hydrolysis and solution. Calcium-ion takes its place, and the soil gradually becomes permeable, although the change is not marked until the last traces of exchangeable sodium have been eliminated. As the American alkali-land farmers put it, "a very little alkali is all too much".

There is another factor, in addition to exchangeable sodium, that greatly affects the permeability of alkali soils; it is the formation, precipitation and accumulation of colloidal hydrous alumina and alumino-silicates within the soil, which lead to its "freezing up" or congelation.

When pure aluminium-salt solutions are rendered alkaline by addition of sodium hydroxide, precipitation of hydrous alumina occurs at reaction values lying between about pH 5·0 and pH 8·5. Above pH 8·5, the precipitate is increasingly dispersed, forming more or less soluble sodium aluminates. This satisfactorily explains the heavy downward leaching of soluble alumina in highly alkaline soils. As leaching proceeds, soil alkalinity is gradually diminished. When the reaction of the sub-soil has been lowered within the insolubility range of alumina (pH 8·5 to pH 5·0), alumina will be precipitated as a highly gelatinous substance that effectively seals the sub-soil, and completely prevents the passage of water. Within the subsoil zone, soluable alumina might sometimes interact with soluble silica, presumably brought down through the operation of similar or other agencies, and mutual precipitation may occur with the concomitant formation of gelatinous alumino-silicates.

It is difficult to prescribe field procedures that would counteract these results. One method, however, has been suggested, namely alternate drying and wetting, which is known from laboratory experience, to effect a gradual irreversible dehydration of colloidal alumina and alumino-silicates. Hence deep cultivation and under-drainage, coupled with alternating dry fallowing and wetting (utilising rainfall or irrigation water), may prove very efficacious if persistently practised. The procedure could at least be applicable to restricted areas, such as "slick spots" or "gall patches" which abound in alkali-soil regions. Furthermore, aluminium salts, such as alum, applied to alkaline soils under suitable conditions, appear sometimes to improve their physical state. Whilst there is some practical evidence supporting this contention, the results appear not to be lasting, and the explanations offered are obscure.

5 RECLAMATION BY IRRIGATION

There is only one practical way of reducing the salt content of saline and alkaline soils, namely by flooding and draining. Where the salts consist of the sulphate, chloride and nitrate of calcium, little difficulty is experienced in reclamation. Where the salts are mainly sodium salts (chloride and sulphate), irrigation with water rich in soluble calcium compounds is also usually effective, but irrigation with *pure water* invariably ends in failure, the soil rapidly becoming impermeable and no longer "taking water" readily. An adequate dressing of gypsum applied to these soils may sometimes alleviate the trouble, as has already been indicated, but usually the quantity of gypsum required is relatively great. Irrigation with water containing sodium salts even in small amounts, eventually is harmful and should be avoided. Seepage of saline water from higher levels must be prevented during irrigation. The likelihood of injury through irrigation and seepage depends partly on soil texture, a well-drained sandy soil being less susceptible than a badly-drained heavy soil.

6 NUTRIENT RELATIONS

(a) *Phosphate.*—Alkaline soils, including normal highly calcareous soils (Rendzina), yield large amounts of prosphate to extracting agents, such as various dilute acids usually employed for its assessment in laboratory studies. Nevertheless, crops grown thereon generally show marked response to soluble phosphatic manures (acid super-phosphate; Nicifos; Ammophos), but

rarely show response to *insoluble* phosphatic manures (rock phosphate, basic slag, bone-meal). Failure to respond has been attributed in most instances to lack of carbon-dioxide in alkaline soils (especially "black alkali" soils) containing insufficient organic matter, and insufficiently aerated. Soil water-extracts or the soil solution, expressed from alkaline soils by suitable displacement methods, seldom show more than traces of phosphate (1 to 3 p.p.m. of solution). The high solubility of soil phosphates in acidic reagents indicates that phosphate will be readily transferred to the soil solution, provided a sufficiently low pH value is attained (for example, pH 6·2 or 6·4). Phosphate solubility diminishes as pH value rises; at reaction values between pH 8·0 and pH 8·5, phosphate is almost insoluble, and may exist in alkaline and calcareous soils chiefly as a specific calcium phosphato-carbonate compound. In the presence of hydrous alumina, phosphate may also suffer fixation as an alumino-phosphate compound, but this is much more insoluble in normal calcareous soils than it is in black alkali soils whose alkalinity reaches high magnitudes. Sodium salts that occur in many alkaline soils and in saline soils depress the solubility of phosphates, and leaching, accompanied by thorough drainage, will therefore often improve the phosphate status of these soils.

The phosphate-supplying ability of a soil (i.e., its capacity for maintaining an adequate rate of delivery of phosphate to plants), varies with soil conditions (including soil reaction), but it is also influenced by plant growth-processes. Thus solvent root excretions, particularly carbonic acid, increase the availability of soil phosphate in the immediate vicinity of plant roots (by reducing the reaction to about pH 6·2 or 6·4) and rapid root absorption lowers the phosphate gradient, so that phosphate uptake may reach adequate magnitude, even in somewhat alkaline soils. Any factor (for example, decomposing organic manure) that increases the carbonic acid content of the soil surrounding plant-roots may aid in the solubilising process. Nevertheless, plants seem to differ in the "feeding power" of their roots, for some species are apparently able to abstract more phosphate from an alkaline or calcareous soil than others.

The phosphate relations of highly alkaline unproductive soils (black alkali soils) are peculiar. Although soil phosphate is insoluble within the reaction range pH 8·0 to 8·5, it readily dissolves at reactions higher than pH 8·5, probably through the formation of sodium phosphates. Reclamation of these soils by cultivation and irrigation does not at once reduce their high content of soluble phosphate, and crop-plants may utilise it, provided other conditions are favourable to normal root absorption. Eventually, however, the re-solution of residual phosphate may become negligible, and fertility may diminish accordingly.

Quite apart from its effect on the solubility of phosphate, soil reaction appears to exert marked influence on the process of absorption of phosphate by plant-roots. Evidence has been adduced from water-culture experiments which demonstrate that little phosphate absorption by plant-roots actually takes place at reaction values above pH 7·6, except in those cases where the diffusion of carbon-dioxide is sufficiently rapid adequately to reduce alkalinity in the region of root contact.

This observation is in accord with earlier results which have indicated that hydroxyl-ions are increasingly injurious to plants at concentrations represented by reaction values greater than about pH 8·2.

(b) *Nitrate and Potash.*—The results obtained for phosphate absorption by plants placed in media of different reaction values, have been closely reproduced for nitrate and potash absorption under similar circumstances. Alkaline reactions apparently greatly depress the absorption of nitrate and potash, as well as phosphate, so that, without the aid of carbon-dioxide within the root-zone, plants cannot obtain adequate supplies of these nutrients from highly calcareous soils and alkaline soils. Whether they can absorb and utilize ammonium-ion under these conditions, however, seems not yet to have been determined.

IV SUMMARY AND CONCLUSIONS: CAUSES OF INFERTILITY IN SALINE AND ALKALINE SOILS

During recent years, there has been a marked tendency to stress more and more the profound deleterious effects of "black alkali" on the physical properties of alkaline soils in the field, and to minimize its direct toxic action. Detailed studies have demonstrated that, with the usual degree of moistness that obtains in field soils, and near the wilting point of plants, soil alkalinity is seldom excessive, even though laboratory examination, under imposed conventional conditions, may indicate high reaction values. When black alkali soils are subjected to thorough leaching by irrigation and drainage, and are afterwards adequately tilled, dressed with gypsum, and treated with organic manures their fertility generally improves and satisfactory crops may be grown on them. Their high reaction values are thereby reduced, at least within the root zone, to magnitude below the limits of alkali tolerance (pH 7·6 or 7·8). The chief agency producing this result is apparently carbon-dioxide, generated by the decomposition of soil organic matter under suitable conditions of aeration.

In the case of saline (white alkali) soils, circumstances are somewhat different. Under low moisture field conditions, salts may become concentrated in the soil water until the limit of tolerance is reached, where plants fail to grow because of the operation of osmotic and dehydrating effects. The toxic limit in most cases of crop-plants appears to lie in the region of 1,000 parts of common salt (and less than 1,000 parts of sodium sulphate) per million parts of soil-solution. For field soils, containing some 20 per cent. of "free" water, this value represents about 5,000 parts per million of *oven-dry* soil. Even though the surface soil may not contain salt in toxic concentration during moist conditions, desiccation may raise highly saline subsoil-water into the root-zone. This effect, however, seems also to have been over-estimated, for direct evidence has accumulated in recent years which indicates that capillary uplift is only effective when the water-table lies within 2½ feet of ground level for heavy-loam soil, and one foot for coarse sandy soil.

The nutritional disorders accompanying alkalinity in alkaline soils, especially calcareous soils, have lately received special consideration. Recent investigations have demonstrated that, under alkaline conditions (pH values greater than about pH 8·0), soil phosphate is immobilised as insoluble compounds involving calcium carbonate and alumina. Highly

calcareous soils may also fix iron oxide and manganese oxide, so that plants growing thereon may suffer marked chlorosis, through lack of adequate chlorophyll formation.

The uptake of nutrient-ions (phosphate, nitrate, potash) by plant-roots is greatly reduced when the alkalinity of the soil solution exceeds magnitudes represented by pH 7·6 or pH 7·8. In highly alkaline soils (reaction values above pH 8·5), aluminium may exert direct toxic action through the formation of aluminates.

It is evident, therefore, that the main factor responsible for the infertility of alkaline soils is their unfavourable reaction. Soils whose reaction values lie above pH 7·8 or pH 8·0 should be regarded with suspicion, and suitable steps should be taken to reduce their alkalinity. In the case of *saline* soils, uncomplicated by reaction effects, mere removal of salt excesses by leaching should prove effective in their amelioration.

THE PRODUCTION OF SILAGE*

INTRODUCTION

THE importance of the production of silage to form a supplementary feed for cattle, as the succulent portion of the ration in semi-arid countries, has now being definitely established. In times of drought and the consequent shortage of pasture and green feeding stuffs, the value of silage is enhanced out of all proportion to its cost of production, which, especially by the "pit" or "trench" method, is by no means prohibitive.

The purpose of this leaflet is to lay before farmers in Cyprus the fundamental principles underlying the production of silage in order that they, in common with farmers in other dry-land countries, may take advantage of this method of preserving succulent fodder for their animals. Silage may be used at all times, as a cattle feed, but it is especially valuable in times of shortage of other green feed; it contains a comparatively high quantity of digestible nutrients and, if properly made, is very palatable to stock.

Ensilage is simply a process by which green and succulent plant materials are preserved for cattle feeding, by placing them in airtight chambers, stacks or pits. The underlying principle in all three systems is the exclusion of air.

CROPS TO GROW FOR THE PRODUCTION OF SILAGE

The best crop to grow under Cyprus conditions for the production of silage is maize and a brief account of the cultivation of this crop is given below. The crop should be cut in a less mature state than is required for the production of grain, viz., it should be cut when it is just coming into cob, so that much of the succulent material may be preserved.

THE CULTIVATION OF MAIZE

(a) Soil Preparation

A thorough preparation of the soil is essential. Where possible, the land should be ploughed as soon as the previous crop has been taken off, as this facilitates weathering, and leaves the soil in a receptive state for the early rains. Before planting the land may, with advantage be cross ploughed to a lesser depth and in any case the soil should be worked down to a fine tilth, to destroy weeds and form a suitable seed bed.

(b) Planting

The seed may be broadcast, but this practice is wasteful and not particulary efficient, and for this reason is not recommended if it can possibly be avoided. In Cyprus there are no mechanical maize planters, such as are used in the great maize-growing countries, but in the long run the farmer will probably find that it pays him to plant the seeds in rows by hand. Should the area be too large for this to be done economically, however, it might be necessary to resort to the broadcasting method.

* From Leaflet No. 19, Department of Agriculture, Cyprus.

The seed should normally be planted 1 to 3 inches below the surface, the greater depth for lighter soils, in rows $2\frac{1}{2}$ to $3\frac{1}{2}$ feet apart to allow room for the inter-cultivation. The seeds should be so spaced as to give the plants a distance between them of from 12 to 20 inches in the row.

The rate of seeding will normally be about 3 to 5 lb. of seed per donum, with considerably larger quantities required if broadcast (12 to 20 lb. per donum). The date of planting will necessarily vary in different parts of the Island, and the best conditions for the growth of the young maize plant can only be determined by observation based upon experience in the district in question. In Cyprus, it will probably be necessary to plant considerably after the commencement of the rains in order to avoid getting the seedlings through in the coldest part of the year.

Under Cyprus conditions, maize also be grown as a Summer crop under irrigation and when this is done the land may be prepared in advance, as required, and sowings made in March and continued until July. In the late sowings the grain will not mature, but if the crop is being grown for the production of silage, this does not matter.

(c) Manuring

Productive maize soils are almost invariably characterized by a high content of organic matter; where this is deficient, as evidenced by the deflocculated and light colour of the soil, it must be remedied by the application of large quantities of stable or goat or sheep manure or by green manuring. It is not usually a practical proposition to apply commercial nitrogenous fertilizers, potassic fertilizers, phosphates or lime, unless the soil is known to be deficient in one of these constituents.

TYPES OF SILOS

There are three methods of producing silage in common use in other countries, according to whether the material is stored in a tower, a stack or a pit silo. The former is probably the best method, but the initial cost of erection puts it beyond the reach of many farmers, who find one of the two latter methods almost as satisfactory. The most convenient type of silo for use in this Colony will probably be found to be the "pit" silo or the "trench" silo which are similar in operation and easy to construct.

THE TOWER SILO

A tower silo may be built of concrete, stone or wood and is usually 20 to 30 feet in height and 10 to 15 feet in diameter, with a door at a convenient level for the silage to be forked out when required for feeding. The maize is run through a chaff cutter and elevated to the top of the silo by means of a "blower". A man inside the tower sees that the material is evenly distributed and trodden down, and the pressure of the top layers brings about the necessary exclusion of air.

THE PIT SILO

Pit silos are inexpensive in construction and for this reason are the most popular type. In these, the ground located in a well drained situation is excavated, leaving somewhat sloping sides 10 to 12 feet in depth and of varying capacity.

The maize may either be put in whole, with the stem ends nearest the walls, or it may preferably be passed through a chaff cutter which facilitates close packing. When properly settled, a layer of grass covered by about 2 feet of soil should be used as a covering, and when starting to feed, the pit should be opened from the side and the silage cut vertically.

A simple modification of the pit silo is the "trench" silo, in which a trench about 5 feet deep and any desired width and length, is employed for making the silage. The trench is filled the same way as the pit silo and covered with a layer of earth which should be about 2 feet thick.

Almost any size of silo may be made for the production of silage by the methods described above, but if very large quantities of silage are required, it is better to have two moderately-sized silos than one very big one, as the moderately-sized silos facilitate feeding. Suggested dimensions for a trench silo are 20 feet long by 10 feet wide by 5 feet deep, but as has before been stated, almost any measurements may be adopted.

THE STACK SILO

Although the methods of producing silage described above are probably superior, the necessity for the construction of expensive tower silos and less expensive pit silos was removed by the discovery that silage may be made successfully in stacks, similar to hay stacks, and subjected to pressure by relatively inexpensive processes. When silage is stacked in this manner, chain presses, hydraulic presses or lever presses may be applied, if convenient; otherwise poles may be pitched and braced in position, with a super-imposed cover of boards heavily loaded with bricks or other weights.

In the case of a stack silo, the whole maize is used and built into stacks 20 to 25 feet diameter or less and 12 to 15 feet or less in height, with the stem ends outwards. This done, the whole is covered with straw and weighted down either as described above, or by simply placing a layer of heavy stones on the top of the stack, and the sides are trimmed down to present an even surface.

TYPES OF SILAGE

Whether sour silage or sweet silage results from the operation of making, is determined mainly by the temperature at which fermentation takes place within the mass of herbage. The temperature is largely regulated by the pressure and the amount of oxygen present within the silage.

Silage is sour or sweet according to the amount of certain organic acids present on the sample, principally acetic, lactic and butyric. If a stack silo is viewed in section from top to bottom, the upper layers will be seen to be more brown in colour than the lower layers. The lower layers have been converted into sour or green silage because the pressure of the material from above has excluded the air and fermentation has taken place at a low temperature. As there exists a lower pressure in the upper layers, freer access of air has given rise to a higher temperature fermenation, killing the organisms, which under conditions of less heat set up an acid fermentation, sweet silage resulting.

The best silage is made at about 130 degrees (F.) and is neither sweet nor sour; silage made below 90 degrees (F.) is inclined to be too sour and is unpalatable to stock, whilst that made above 160 degrees (F.) is burnt and also unpalatable to animals.

THE FEEDING OF SILAGE

Silage can be made in all kinds of weather and is capable of affording a succulent and nutritious feed to stock at all seasons of the year; it may be fed at any time after it has been placed in the silo and will keep good for years if well secured and sealed in whatever type of silo is used.

Well made silage may be regularly used by the stock breeder in addition to other feeding stuffs, but care should be taken to prevent scouring, which may occur if too liberal amounts are included in the ration. A good rule to observe is to give 3 lb. of silage a day for each 100 lb. live weight of the animal, in the case of dairy stock; yearling heifers consume about half as much as mature stock. For horses and mules the amount fed should not usually exceed 10 to 15 lb. per head daily, whilst fattening bullocks may receive as much as 4 lb. per 100 lb. live weight.

The United States Department of Agriculture states that no cheaper or better roughage can be fed to a breeding flock of sheep than good maize silage, which furnishes the succulence so necessary to the health and vitality of the ewes. A good quality of silage is very palatable and quantities ranging from 1 to 5 lb. per head per day have been fed in different feeding trials with good results.

Silage is especially useful in supplying the bulky portion of the ration when hay, straw and green food is scarce.

REVIEWS

RECENT ADVANCES IN AGRICULTURAL PLANT BREEDING

[*Recent Advances in Agricultural Plant Breeding* by H. Hunter and H. M. Leake (London Messrs. J. and A. Churchill, 1933) 15 shillings].

THIS book is a compilation of the encyclopaedic type. It conveys plainly on almost every page that the authors set out with the idea of making a book rather than of writing one from a storehouse of zeal and learning.

Not the least interesting reading in the volume is the Foreword by Sir Rowland Biffen. An attempt is made in the introduction to marshal the differences between the breeding of tropical and temperate-climate crops. That temperate-climate cultivation has become specialized to such an extent that permanent plants like fruit trees have been assigned to a division of study of their own horticulture, and that tropical agriculture includes permanent crops such as rubber, cacao, coffee, tea, hardly introduces a difference in itself in the lines of plant breeding in the two zones. The methods pursued in controlled multiplication of rice, citrus and cacao are not different from those followed with wheat, apples and filberts. The attempts to make a distinction without a difference is somewhat laboured. Perhaps it is made more by way of an apology to explain the total omission of fruit crops from Part I and their inclusion in Part II. The fundamental point at the root of the matter is the same—the raising of bush and tree crops, be they gooseberries or apples, rubber or coffee is the agriculture of perennial crops requiring capitalistic venture, and therefore often associated with the plantation system and colonial expansion as opposed to the raising of annual crops in a system of peasant production. The perennial usually introduces the problem and opportunity of vegetative reproduction that is all, and vegetative reproduction presents the same aspects in both tropical and temperate zones.

There is a general attempt to compress far too much information into some of the chapters whilst others, like those on coffee, tea, and poppy, contain but little and are included apparently solely to avoid a break in the encyclopaedic nature of the treatment.

Few of the illustrations are original to this volume. The volume is essentially a panorama of plant breeding with a selection of references to some of the important original work on each crop. To those requiring such a book it can be recommended.

THE EMPIRE MARKETING BOARD'S COPRA SURVEY

THE coconut palm is one of the most important sources of food and raw material in the domestic economy of those who live in the tropics. This point is brought out by the Empire Marketing Board in the second volume of a *Survey of Oil Seeds and Vegetable Oils,* which deals specifically with "Coconut Palm Products". (H.M. Stationery Office 2s. 0d. net). These include copra, coconut oil, fresh coconuts, desiccated coconut, coir and coconut cake and meal.

Copra, the white kernel or "dried coconut meat", has a high oil content, and is the most important commercial product of the coconut palm. The Survey deals mainly with the production of, and trade in, copra and coconut oil.

More than 1,000,000 tons of copra are now annually exported from the various producing areas, and of this amount the British Empire furnishes about 40 per cent., principally from the British South Sea Islands, British Malaya, and Ceylon. Ceylon copra realizes a higher price than the produce of other areas because it has a better appearance, a higher oil content and is more regularly graded before being marketed.

The principal foreign countries growing coconut palm are the Philippine Islands and the Dutch East Indies. The copra produced in the latter Islands is not of uniform quality and is somewhat inferior to that of Ceylon, although on the whole, superior to the South Seas and Philippines product. The average oil-content of its "fair, merchantable, sun-dried" copra is estimated at 66 per cent. as compared with 68 per cent. in the case of Ceylon, and 67 per cent. in the case of the South Seas.

After reviewing the countries producing and exporting coconut palm products, the Survey considers the copra-importing countries, first of the British Empire and then of the world. The United Kingdom at present ranks fifth in the list, being preceded by the United States, France, Germany and the Netherlands. Her imports, however, in this commodity have been increasing appreciably during recent years, whilst those of other countries have tended to be stationary. The larger part of the imports of the United Kingdom is derived from Empire countries.

The Survey also gives the course of prices of copra and coconut oil over a period of twenty years, and arrives at the following conclusions:

Coconut Oil derived from copra is by far the most important ultimate product of the coconut palm, and the future prospects of the industry depend almost entirely upon the demand for the oil. Within the last ten years there has been an increase of about 30 per cent. in the world acreage under coconuts, bringing the total to 7¼ million acres in 1931. Since 1921 British Empire countries have accounted for slightly more than half this amount. The increase noted has been largely due to the developments in the United

States, but the needs of that country can be, and are, met by the production from the Philippines. Other producing countries must be chiefly dependent upon European consumption. It follows therefore that any decrease in the American demand releases Philippines production to enter into competition in the European market, where, owing to the heavy production of whale oil, there is no present sign of an increased demand.

The demand for coconut oil depends upon the expansion of the soap and margarine industries, which in their turn depend upon the growth of populations and a rise in their standards of life. The prospect of the increased utilisation of any particular oil or fat in these industries cannot be easily defined. Much depends upon price considerations, and efforts are being made to reduce the costs of competing vegetable oils against the probable rise in price of animal and marine fats.

There is every indication that the output of copra will be on the increase for several years, and that the bulk of this will appear on the world market, although local consumption accounts for a considerable proportion of the output of most producing countries, as in India, the Dutch East Indies and South Sea Islands. The Philippines are a notable exception.

Annual world exports from producing to consuming centres during the pre-war quinquennium aggregated 391,500 tons of Coconut Oil and Copra in Oil equivalent. The peak was reached in 1929 with 1,012,000 tons. Since then there has been a decline, but it is thought that there will again be an upward trend as the new areas under cultivation come into full bearing, and more favourable conditions rule the world market.

MEETINGS, CONFERENCES, ETC.

THE RUBBER RESEARCH SCHEME (CEYLON)

Minutes of the twelfth meeting of the Board of Management, held at 11 a.m. on Thursday, February 16, 1933, in Room No. 202, New Secretariat, Colombo.

Present.—Dr. W. Youngman (in the chair), Messrs. C. W. Bickmore, C.C.S., (Actg. Financial Secretary), I. L. Cameron, C. E. A. Dias, J.P., B. F. De Silva, H. R. Freeman, M.S.C., C. A. Pereira, B. M. Selwyn, E. W. Whitelaw, and Colonel T. Y. Wright.

Mr. T. E. H. O'Brien, Director of Research, was present by invitation and acted as Secretary to the meeting.

Apology for absence was received from Mr. G. K. Stewart, M.S.C.

The Chairman welcomed to the Board Mr. E. W. Whitelaw who had been nominated by the Rubber Growers' Association in place of Mr. J. D. Hoare. He also reported that Colonel G. B. Stevens had been nominated by the Planters' Association to act for Mr. F. H. Griffith during his absence from the Island. Mr. Griffith had now returned and resumed duties.

The Chairman reported that the following decisions had been reached by circulation of papers since last meeting:

(a) *Budding Experiment.*—Decided that the Scheme should confine its attention, for the present, to experiments on its own property.

(b) *Test tapping of new clones.*—Decided to arrange co-operation with estates in test tapping new clones on the lines proposed by the Director of Research.

(c) *Tapping Questionnaire.*—Decided to issue a questionnaire to estates which receive the publications of the Scheme, in order to obtain information regarding the results of new tapping systems.

(d) *Amendments to Provident Fund Rules.*—Decided to accept the amendments proposed by the Deputy Financial Secretary and to adopt the rules of the Fund as amended.

STAFF

The Chairman reported that Mr. Murray had returned from home leave on January 2nd and resumed duties.

A vote of thanks was passed to Mr. M. Park, Government Mycologist, for services to the Scheme during Mr. Murray's absence, and to the Director, Rothamsted Experimental Station for providing facilities for Mr. Murray's course of study leave at that Institution.

ACCOUNTS

Receipts and Payments.—Statement of receipts and payments of the Board for the quarter ended December 31, 1932, was adopted. Statements of expenditure on the Experiment Station for October, November and December, 1932, were tabled.

Night Watchman for Laboratories.—It was decided to appoint a night watchman in view of a minor burglary having occurred at the laboratories.

DEVELOPMENT OF THE RESEARCH SCHEME

The Chairman read extracts from a letter from the Chairman, Rubber Growers' Association drawing attention to the need for research on latex and raw rubber with a view to increasing consumption and suggesting that application should be made for a grant from the Rubber Restriction Fund to provide extra staff for the purpose. After discussion the Board agreed in principle to the need for strengthening the chemical staff of the Scheme and decided to consider the matter later in connection with proposals to acquire an estate.

A letter from the Hon'ble the Minister for Agriculture and Lands in reply to a resolution passed at the last meeting of the Board, was read. The letter indicated that any application for a grant from the restriction fund would be considered on its merits.

A report from the Director of Research on alternative estates which might be suitable for experimental purposes, was considered. The Chairman said there were 3 estates mentioned which might be suitable. It was decided to appoint a Committee consisting of Messrs I. L. Cameron, C. E. A. Dias, F. H. Griffith, B. M. Selwyn and E. W. Whitelaw to visit the estates and report to the Board at a meeting to be held next month.

Visits to estates for advisory and experimental purposes.—With a view to safeguarding the Scheme against possible claims for damages in connection with advisory and experimental work on estates it was decided to adopt a simple form of indemnification to be signed by the Proprietor or Agent of an estate before a visit to the estate for advisory or experimental purposes is undertaken.

REPORTS

Technical officers' reports for the period June to December, 1932, were considered and adopted.

The following reports were tabled :—

"Alternative forms of raw rubber".

"Notes on the after-treatment of budded stocks".

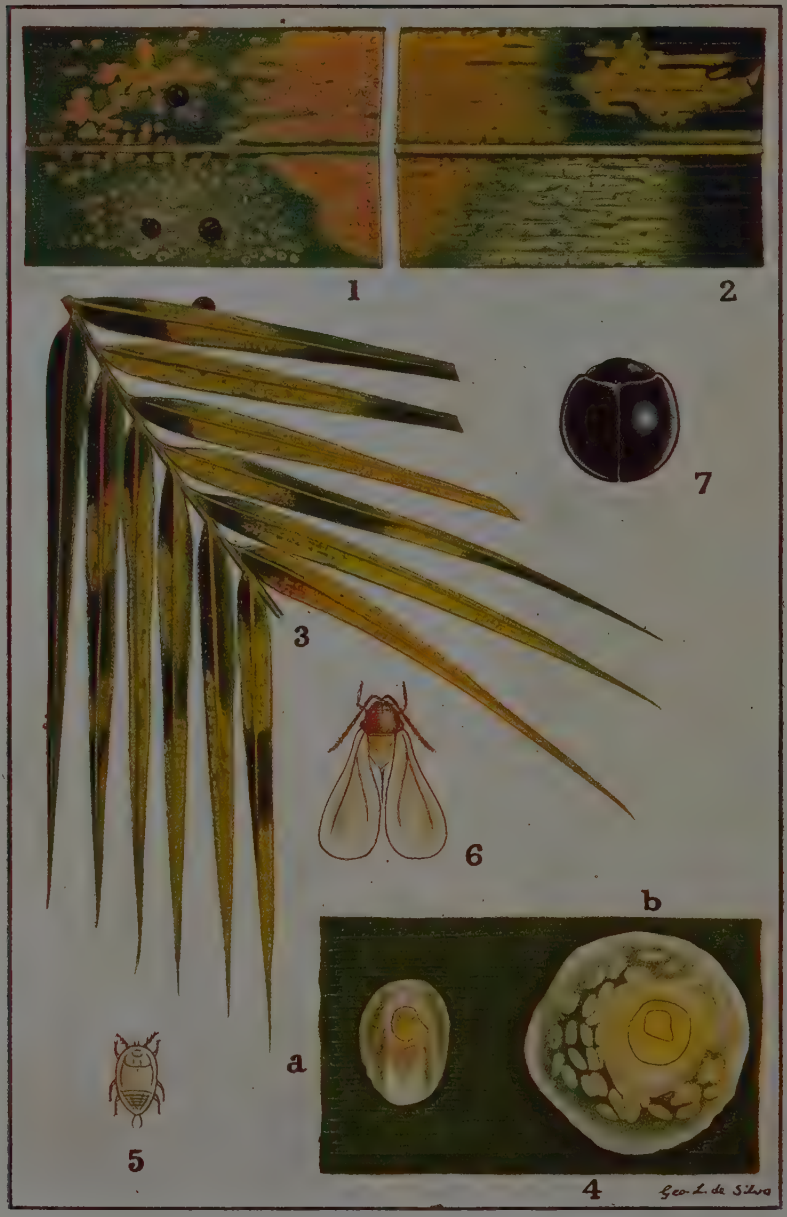
"The effect of earth-cowdung mixtures on renewing bark".

LONDON ADVISORY COMMITTEE

Consideration of the minutes of meetings held on October 28, 1932, was deferred until next meeting.

The following report was tabled :—

"Crepe from coagulum heated with hot water".



The Coconut Scale *(Aspidiotus destructor)*

Fig. 1. Portion of coconut leaflet showing colonies of scales on under surface and lady-bird beetles feeding on the scales.—Nat. size.

Fig. 2. Portion of coconut leaflet with patches of yellow on upper surface caused by scales feeding on under surface.—Nat. size.

Fig. 3. Portion of coconut leaf with yellow patches caused by the coconut scale Reduced in size. A lady-bird beetle is shown, nat. size, on the top leaflet.

Fig. 4. Coconut scales; *a*. adult male scale with wings developed; *b*. adult female scale with eggs. Both scales are covered by a thin waxy film. ×20.

Fig. 5 Young larva or "crawler" of coconut scale. ×20.

Fig. 6. Adult winged male of coconut scale. ×20.

Fig. 7. Lady-bird beetle (*Chilocorus nigritus*) ×5.

Figs. 5 and 6 redrawn from Green, Coccidae of Ceylon, I, pl. VIII.

DEPARTMENTAL NOTES

THE COCONUT SCALE *(ASPIDIOTUS DESTRUCTOR)**

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THE Coconut Scale is one of the most widely distributed scale insects in Ceylon and probably occurs wherever coconuts and other palms are grown. It is by no means confined to this group of plants, but has been recorded from time to time, in small numbers only on a variety of other cultivated plants, including tea, rubber, plantain, mango, pepper, etc., and on many wild plants.

Outbreaks of this scale occur periodically on a few coconut estates on the western side of the Island and occasionally in other coconut areas, and areca palms are sometimes attacked, but these outbreaks are sooner or later controlled by small blue-black lady-bird beetles (figs. 1 and 7) and their larvae which can often be seen on scale-infested leaflets. Very small wasp parasites also attack this scale in Ceylon.

NATURE AND EXTENT OF DAMAGE

The presence of the coconut scale can be detected by the appearance of yellowish patches on the older leaves and when these patches are examined closely they are seen to be mottled yellow and green and to be composed of innumerable small yellow spots, each spot on the upper surface of a leaflet usually marking the position of a scale insect on the under surface (figs. 1 and 2). These scales settle down in small colonies on a leaf, each female remaining attached for the remainder of its life to the same spot by its thread-like beak. This sucking organ penetrates the leaf tissues, gradually exhausting the sap and killing the surrounding tissues which turn yellow underneath each scale. If these original colonies escape the attentions of lady-bird beetles they produce a large number of very small active larvae or "crawlers" (fig. 5), some of which soon settle down around the parent colonies, while others wander on to other portions of the same leaf or are blown by the wind to adjacent leaves or even to neighbouring palms, where they start new colonies. If the breeding of these scales is allowed to continue unchecked for several months, then eventually all the older leaves on small areas of palms are seen to be more or less yellow (fig. 3).

Under Ceylon conditions the coconut scale, owing to the efficiency of its natural enemies, rarely gets beyond the stage of attacking small scattered areas of palms, but in some other countries reports have indicated that this scale regularly caused serious damage to hundreds of acres of coconuts until controlled by the introduction of its natural enemies, mainly small parasitic wasps and lady-bird beetles.

* Submitted as a leaflet.

It should be mentioned here that the mottled yellowing of portions of coconut leaves is quite distinct from another type of yellowing in which the whole leaf becomes evenly tinged with a bright yellow colour. This type of yellowing is usually associated with some soil deficiency and is particularly noticeable in areas where coconuts are growing under naturally poor soil or in areas where manuring or cultivation have been temporarily stopped for various reasons.

BREEDING HABITS

As indicated above the female scales produce numbers of young larvae (fig. 5) which crawl about looking for a place on which to settle down, almost invariably on the underside of a leaflet. These very small, oval, pale-yellow larvae, after settling down, attach themselves to the leaf surface by means of their sucking beaks and cover themselves individually with a thin transparent film of waxy material. Then they moult, throwing off their legs in the process. After this first moult the two sexes become marked off, each sex developing on different lines. The *males* remain small and oblong, feeding and moulting for the second time into the pupal stage, during which stage the legs and wings develop. Each male emerges from its pupal skin under the thin waxy covering, and, after expanding its wings, (fig. 4a) finally comes out as a very small winged insect (fig. 6).

The *female* scale, after the first moult, increases in size and broadens out, gradually enlarging its thin waxy covering. It reaches the final adult stage without any great change in external appearance except in size and is partly hidden under the two moulted skins (fig. 4b). It then becomes sexually mature and rapidly increases in size as the eggs develop inside the body. The thin covering is extended so as to cover not only the scale itself but also the eggs which are laid in a ring around the body, up to about 50 in number (fig. 4b). These eggs soon hatch into the young larvae which crawl out from under the thin covering and the whole life-cycle starts all over again.

It is probable that in the warm climate of the main coconut areas this scale can go on breeding continuously all the year round, although the development may be somewhat retarded during long wet periods. The females are usually produced in far greater numbers than the males, but occasionally one finds a leaflet on which the males considerably outnumber the females.

CONTROL MEASURES

Palms which are naturally vigorous and which are growing under suitable soil conditions are less liable to get serious and prolonged attacks of coconut scale than those growing under poorer conditions, and if the attack is checked in the early stages by natural enemies or by artificial measures of control these palms are able to recover more rapidly from the effects of the injury than is the case with weaker palms.

Remedial measures.—It is sometimes difficult to be certain of the presence of the coconut scale on older and taller palms, but if there is any doubt, the removal and examination of a few of the older leaves here and there should decide the matter. It should also then be possible to discover whether the lady-bird beetles are at work, either by observing the beetles themselves or by noting any patches where the scales have been eaten away. If the beetles are found to be present during the early stages of an attack they can usually be relied upon to check any further increase. If, however, the beetles are not in evidence and it is seen that a large number of larvae have recently settled down, then the infested leaves on older palms should be removed and burnt in order to check the spread of the pest, since spraying is not practicable on tall palms. On young palms the attack rarely extends beyond a few small patches on individual leaflets of older leaves, and these infested leaflets can easily be removed or the leaves can be sprayed with kerosene emulsion two or three times at intervals of a week.

It sometimes happens that attacks of the coconut scale recur periodically on much the same comparatively small areas of palms and if this is found to be the case these areas should receive special attention as regards cultivation and manuring. All scale-infested areas should receive such special attention as soon as the attack is noticed, and if the attack persists in the absence of lady-bird beetles, the matter should be reported to the Entomologist, who may possibly be able to arrange for the introduction of the beetles if any are available elsewhere at the time.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31 MARCH, 1933

Province, &c.	Disease	No. of Cases up to Date since Jan. 1st 1933	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	22	...	21	1	...	...
	Anthrax	...	...	...	...	..	...
	Rabies (Dogs)	10	10	...	10	...	...
	Piroplasmosis	...	...		...	...	...
Colombo Municipality	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	28	1	27	1	...	...
	Anthrax	3	1	...	3	...	...
	Rabies (Dogs)	13	5	...	...	...	13
	Haemorrhagic Septicaemia	...	...	...	...	...	...
	Black Quarter	...	...	...	...	...	...
	Bovine Tuberculosis	...	...	...	...	...	
Cattle Quarantine Station	Rinderpest	...	...	...	...	..	...
	Foot-and-mouth disease (Sheep & Goats)	70	38	48	3	19	...
	Anthrax (Sheep & Goats)	64	34	...	64	...	...
Central	Rinderpest	34	17	3	22	7	2
	Foot-and-mouth disease	3	3	2	...	1	...
	Anthrax	9	1	...	9	...	..
	Black Quarter	...	...	...	...	...	...
	Rabies (Dogs)	...	...	...	...	...	...
Southern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	50	...	50	...	...	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	...	...	...	...	...	...
Northern	Rinderpest	123	86	15	97	9	2
	Foot-and-mouth disease	4	..	4	...	...	...
	Anthrax	...	...	...	...	...	...
	Black Quarter	..	...	...	...	...	...
	Rabies (Dogs)	...	...	...	...	...	...
Eastern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	52	...	51	1	...	...
	Anthrax	...	...	...	...	...	...
North-Western	Rinderpest	...	...	...	...	..	...
	Foot-and-mouth disease	3	...	3	...	...	...
	Anthrax	...	...	..	...	...	...
	Pleuro-Pneumonia (Goats)	3	3	...	1	...	2
	Rabies (Dogs)	1	1	...	...	...	1
North-Central	Rinderpest	684	214	105	529	39	11
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	...	...	...	...	...	...
Uva	Rinderpest Foot-and-mouth disease Anthrax Rabies (Dogs)	FREE					
Sabaragamuwa	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	..	...	...	...	...	...
	Piroplasmosis	...	...	...	...	...	...
	Haemorrhagic Septicaemia	3	1	...	3	...	...
	Rabies (Dogs)	...	...	...	...	...	...

G. V. S. Office.
Colombo, 12th April, 1933.

M. CRAWFORD,
Govt. Veterinary Surgeon.

METEOROLOGICAL REPORT

MARCH, 1933

Station	Temperature				Humidity		Amount of Cloud	Rainfall		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Inches		Inches
Colombo	87·2	− 1·2	73·6	− 0·4	70	93	4·6	2·40	4	− 2·12
Puttalam	90·5	+ 0·7	72·5	− 0·1	68	93	3·0	0·67	1	− 2·30
Mannar	88·4	− 2·2	74·8	− 0·2	68	88	3·8	0·36	1	− 1·08
Jaffna	88·0	− 0·5	73·8	− 1·1	70	93	2·8	1·38	4	+ 0·23
Trincomalee	84·6	− 0·7	77·5	+ 0·9	74	82	3·4	1·32	2	− 0·42
Batticaloa	85·4	+ 0·1	75·0	0	74	90	2·9	0·92	2	− 2·25
Hambantota	87·3	+ 0·3	73·8	− 0·2	71	90	2·7	0·72	6	− 1·84
Galle	86·3	− 0·8	74·9	0	76	93	4·1	2·98	12	− 1·68
Ratnapura	92·2	− 0·1	72·8	+ 0·2	69	93	5·6	9·78	19	+ 0·80
A'pura	90·5	− 0·7	71·9	+ 0·3	61	93	5·0	1·58	4	− 1·33
Kurunegala	91·8	− 1·3	72·0	− 0·4	60	93	5·3	5·67	7	+ 0·54
Kandy	86·9	− 0·9	67·9	− 1·1	66	92	3·8	7·72	10	+ 3·53
Badulla	81·8	− 0·5	64·4	+ 0·1	70	94	4·6	2·17	10	− 2·44
Diyatalawa	76·9	− 0·4	58·5	+ 1·0	67	88	5·4	2·39	9	− 1·93
Hakgala	72·5	− 0·8	51·0	− 1·6	74	94	4·5	2·71	11	− 2·87
N'Eliya	70·7	− 0·3	45·6	− 0·6	62	86	4·8	5·16	8	+ 1·68

Excesses and deficits of rainfall were fairly irregularly distributed during March but, on the whole, deficits predominated, particularly in the low-country. In the central parts, however, and more particularly in the Kandy District, an appreciable number of stations registered excesses ranging up to 5 inches. The only two stations that were more than 5 inches in excess were Hallayen and Rasagalla, both in the Sabaragamuwa Province.

The majority of stations recorded slight deficits, and only about half a dozen, all in the southern half of the Island, were as much as 5 inches below average.

The highest totals for the month were 18·10 inches at Carney, 17·73 at Mawarella, and 17·28 at Rasagalla, the other stations with over 15 inches for the month being Blackwood, Dabar and Dik Mukalana. Practically all these lie on the western and southern slopes of the central hills.

Most of the rain fell during the second half of the month and was chiefly the result of local thunderstorm activity.

There were only four falls of over 5 inches in a day, the highest being 6·85 inches at Peradeniya Experimental Station on the 11th-12th, on which day the gauge at Katugastota recorded 6·83 inches, the next highest fall during the month.

Temperatures were on the whole a little below average for the month, while humidity was above normal.

Wind was above average strength, and generally north-easterly.

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